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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

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GENERAL PHYSICS.

348. *Clock of Precision.* **C. O. Bartrum.** (Phys. Soc., Proc. 39. pp. 120–146; Disc., 147–148, Feb. 1917. Engineer, 123. pp. 161–162, Feb. 16, 1917.)—The principal feature of the author's arrangement is the employment of a "slave" clock to do the great part of the work, leaving the master pendulum no function beyond that of controlling the rate of the other. The master pendulum swings freely except for a short period (about 1/5 sec.) every minute, during which it receives an impulse from a small falling wheel electromagnetically released by the slave clock. At the end of its fall the impulse mechanism closes a second circuit and is restored to its initial position. These two electric circuits also energise parts of the mechanism of the slave clock, by which the latter is kept in time with the master pendulum. The lagging of correction behind error, with the resulting periodic fluctuation in the rate, is reduced almost to vanishing point by the introduction of a "negative backlash" in the control mechanism. A mathematical discussion is given of the best working conditions, and of the possible magnitude of errors which might arise from various causes. In the *discussion,* **C. V. Boys** suggested various devices which would attain the same ends as Bartrum's arrangement. A. W.

349. *Foucault Pendulum.* **C. Barus.** (Science, 45. pp. 265–270, March 16, 1917.)—In view of the relatively large angular velocity of the earth, it should be possible to exhibit this rotation by aid of the Foucault pendulum in a few minutes, and this in such a way that reasonably accurate quantitative results may appear. As the pendulum partakes of the rotation of the earth it is useless to attach mirrors to the bob. Further, the combinations of a Foucault pendulum and a horizontal pendulum, or of a large pivoted balance beam with two identical pendulums at its ends will lead to no solution of the problem.

The paper then deals with an objective method of observation. For this the pendulum should be 4–5 m. long, the bob 3–6 kg., the amplitude about 15 cm. A lens of focal distance about 60 cm. is placed about 70 cm. from the resting position of the bob, so as to focus it upon a screen about 6 m. distant from the lens. Then the apparent rotation of the plane of vibration will be shown on the screen by the shifting of the bob's positions. An electrical method is also described. E. H. B.

350. *Deformation of Elastic Water-filled Containers and of Elastic Diaphragms under Pressure.* **F. Rode.** (Zeits. Instrumentenk. 37. pp. 18–30, Jan., 1917. Dissertation, Aachen, 1915.)—Investigates the best form of container to give a small hysteresis effect in the relation between deformation and pressure, and concludes that it is essential that under both increasing and decreasing pressures the actual pressing surface shall have the same area at the same pressure. Both container and diaphragm if properly designed are capable of giving useful results, but the diaphragm is, on the whole, to be preferred. J. W. T. W.

351. *Oscillations of Gun-barrels.* **M. Ôkôchi** and **M. Majima.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 41–49, Feb., 1917.)—Various researches have been made on gun-barrel oscillations, but these have been concerned with the transverse oscillations. The present paper deals with the latter and also the longitudinal and torsional oscillations. Numerous tables of experimental results are given, and from these it is shown (i) that only the transverse oscillations have any appreciable effect on the shooting powers of the gun, the the others producing no modification at all. (ii) The duration of the transverse oscillations of a gun-barrel corresponds fairly well with that of a pointed cone of height equal to the length of the barrel. (iii) The torsional oscillations start as soon as the shot begins to move, and so it is possible to calculate the length of time taken by the shot in traversing the length of the barrel. (iv) The pressure on the shot at the muzzle can also be estimated from an investigation of the longitudinal oscillations. A. W.

352. *The Influence of Speed on Endurance Tests.* **W. C. Popplewell.** (Engineer, 122. pp. 339–340, Oct. 20, 1916.)—It is still an open question as to whether or not the rate of reversal in alternating-stress tests has any effect on the results obtained. The author has therefore made a series of tests with a view to determining the shape of the hysteresis loop when different rates of testing are used. The results show that the loops obtained at very slow speeds are wider than those obtained at higher speeds. During a complete cycle it appears that the high speeds result in a smaller positive disturbance of the material than do the low speeds. At the same time the high speeds result in a greater residual strain; but since this negative strain is less than the positive strain the net result is lowered as the speed of the test increases. High speed, therefore, should result in greater endurance—a conclusion which is borne out in practice by the work of a number of investigators. The uniform results obtained by Reynolds and Smith are probably due to their machine being slightly out of balance. F. C. A. H. L.

353. *Erosion of Guns: the Hardening of the Surface.* **H. Fay.** (Am. Inst. Mining Eng., Bull. No. 120. pp. 2237–2251, Dec., 1916.)—A detailed study of a worn 12-in. gun tube has been made with a view to throwing light on the behaviour of the surface in becoming hard and brittle; causing cracking and erosion during use. Examination of rings cut at various points along the length of the tube showed that the greatest amount of wear, and the max. thickness of hard surface-layer, was found in the ring cut close to the powder chamber; a ring cut 12 in. nearer to the muzzle showed the greatest number

of and deepest cracks, after which, there was progressively less effect towards the muzzle. At the muzzle the sole effect was the production of heat cracks on the driving edge of the bands only. The hardening may be produced by three causes: (1) cementation, (2) rapid cooling of the heated surface layer by the great mass of material, (3) mechanical deformation. Microscopical examination of sections treated in various ways indicated that all three actions take place during the passage of the projectile and the gases.
F. C. A. H. L.

354. *Stresses in Impact.* **A. Elmendorf.** (Frank. Inst., J. 182. pp. 771–790, Dec., 1916.)—The author has investigated mathematically the stresses set up in beams under bending impact, and has confirmed his work by experiment. A series of force-deflection curves for timber broken under a single blow on being compared with curves obtained in static bending, show that the impact fibre-stresses are almost double the static stresses at rupture. The energy of rupture in impact up to the ultimate load is twice that of static bending. The deflection at the ultimate load, and the modulus of elasticity are about one-fourth higher for impact than the corresponding properties under static loading. F. C. A. H. L.

355. *On Maxwell's Stresses.* **M. N. Shaha.** (Phil. Mag. 33. pp. 256–261, March, 1917.)—Maxwell has shown that the mechanical action between two electrical systems at rest can be accounted for by assuming the existence of certain stresses distributed over a surface completely enclosing one of the systems. By this means Maxwell claims to have provided a concrete physical representation of the mechanism of electrostatic action. The expressions deduced, however, are not complete solutions of the integral equation obtained, and Maxwell himself pointed out that they can at best be regarded as a first step towards its solution. Many investigators, including J. J. Thomson, have shown that the ether cannot possibly be at rest under these stresses, and Lorentz opines that the latter are simply mathematical fictions which can be conveniently utilised for the calculation of radiation-pressure and other allied phenomena.

The object of the present paper is to show that the stresses cannot account for the energy of electrification, if the medium is to be regarded as an elastic solid. Maxwell states that the energy of a charged system when expressed as a volume integral may be interpreted as the energy in the medium due to the distribution of stresses, but the statement is not proved. The present author considers that the only rational meaning which can be attached to this assertion is that the energy of electrification arises from the elastic displacement of ether particles, and that energy calculated on this understanding should lead to the volume integral referred to above. Proof is given to show that the latter is not the case, and that Maxwell's stresses fail to account for the energy of electrification on the assumption that the medium behaves like an elastic solid, and unless something definite is known about the elastic constants of the ether no conclusion can be drawn as to the energy distribution therein. The author then shows that the distinction between Maxwell's view of energy distribution (as due to stresses) and the actual case, can be well brought out by a modified method of proving the energy-distribution theorem. Maxwell first predicted on the hypothesis of dielectric stresses that radiant energy would exert a definite pressure on material surfaces. Now that radiation-pressure is an experimental fact, it has been supposed by some physicists that Maxwell's stresses must have a material existence. Radiant energy can, however, be deduced independently of the stresses, since Bartoli has shown that the pressure of radiant energy can be deduced from thermodynamic principles, while Planck has derived it from electrodynamical principles assuming that the perfect reflector is a super-conductor of electricity. This is an ideal limiting case of the experimental fact that good conductors of electricity are also good reflectors of radiant energy. The electric vector accompanying a ray of light gives rise to a finite charge on the surface of the super-conductor and a finite current within the conductor. The charge exerts a negative pressure on the surface, while the current, in presence of the field of the magnetic vector accompanying the ray, produces a mechanical force in the contrary direction. The resultant of the two, when averaged statistically, yields the radiation-pressure. The author suggests that the investigation of how far these theories are consistent with the theory of stresses may be productive of fruitful results. H. H. Ho.

356. *The Flow of Air through Nozzles and Orifices.* **J. L. Reynolds** and **H. J. Ling.** (Am. Soc. Mech. Eng., J. 39. pp. 250–252, March, 1917. Thesis presented to the Leland Stanford Jr. Univ., 1916.)—The first part of the paper contains an historical review of the development of the theory of flow of air through orifices. The second part is devoted to a discussion of the design of needle nozzles. As regards the general theory of the flow of air through orifices and nozzles with special regard to problems of measurement, the authors believe that the main reason why the nozzle-and-orifice method for measuring the discharge of air has been discredited is due to the ambiguous presentation of data by different experimenters, which led to the use of improper coefficients with the given orifices or nozzles in cases where, if proper coefficients had been used, the results would have been satisfactory. Further, the actual discharge of air through a given nozzle or orifice is less than the theoretical discharge under identical conditions of pressure and temperature. This is due to the fact that as a general rule the stream of air has a smaller cross-section than that of the orifice itself; also, because of internal and external frictions, the effective velocity of flow is less than the theoretical value. With the thin-edge orifices the coefficient of velocity is practically unity, *i.e.* the orifice is considered to be frictionless; in which case the coefficient of discharge may be considered equal to the coefficient of contraction. The following are listed as the most important factors which influence the quantity of flow through an orifice: (1) Initial pressure of air supply, and in some cases the ratio of the back pressure to the initial pressure. (2) The shape of the orifice, whether it is cylindrical, conical, of convergent or divergent type, or a combination of the two. The length, or rather the ratio of diam. to length, or if an orifice in a thin plate, whether it is bevel- or straight-edged. (3) The condition of the interior surface—smoothness; and also whether the entrance is well rounded and free from sharp breaks in outline of the nozzle curve.

It appears that the coefficient increases with the initial pressure and also with the ratio of back pressure to initial pressure, and that a short orifice with well-rounded approaches will give a coefficient of discharge of approximately 0·98. Another important factor brought out is that since the time of Zeuner and Fliegner's experiments it has been well established that when the ratio of the final pressure to the initial pressure has a value of 0·527 the discharge is a maximum; for all values less than 0·527 the discharge remains a constant max. value. The authors also consider the problem of designing a needle-nozzle control of air dis-

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charge from a turbo-compressor set to meet given requirements. In connection with this investigation numerous tests were made to determine by actual measurement the rate of discharge of steam through a sharp-edged orifice 0·208 in. in diam. and in a 0·125-in. thick brass plate. H. H. Ho.

357. *Photographic Test of Theory of Relativity.* **A. F. Lindemann** and **F. A. Lindemann.** (Roy. Astron. Soc., M.N. 77. pp. 140–151, Dec., 1916.)—As a promising field of investigation for testing Einstein's theory of the refraction of light by a gravitational field, experiments are described showing that stars may be photographed in full daylight by using red filters in conjunction with red-sensitive plates. C. P. B.

358. *Three Discourses on Diffusion, Brownian Movements, and the Coagulation of Colloid Particles.* **M. v. Smoluchowski.** (Phys. Zeits. 17. pp. 557–571, Nov. 15, and pp. 585–599, Dec. 1, 1916.)—Gives a short but comprehensive survey of the author's theoretical investigations, in order to make clear the internal mechanism of the diffusion process and several related molecular phenomena. L. H. W.

359. *Some Aspects of Recent High-pressure Investigation.* **J. Johnston.** (Frank. Inst., J. 183. pp. 1–33, Jan., 1917.)—A discussion of recent research on high-pressure phenomena. The apparatus employed by the author and Adams in their investigations receives special attention, and details of its construction are given. L. H. W.

360. *Basis of the Kinematics of a Physical Wave.* **K. Uller.** (Phys. Zeits. 17. pp. 610–615, Dec. 15, 1916.)—A further theoretical contribution [see Abs. 854 (1916), 45 (1917)]. L. H. W.

361. *Internal Atomic Field of Lithium.* **A. Hartmann.** (Phys. Zeits. 18. pp. 14–16, Jan. 1, 1917.)—A theoretical treatment of the subject. Taking the lithium atom to possess three electrons, and assuming Bohr's theory to hold for the lithium atom, it is shown that only one of these electrons, probably the valency electron, can rotate about the nucleus, while the other two are found in the immediate neighbourhood of the nucleus. This result Bohr has previously suggested as probable in the case of the lithium atom [Abs. 1980 (1913)]. Further work will deal with the calculation of the internal field of the lithium atom, and with the remaining alkalies. A. W.

362. *The Hydrogen-molecule of Bohr and Debye.* **J. M. Bergers.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 480–488, 1916.)—Miss H. J. van Leeuwen, in a recent paper on Debye's calculation of the dispersion formula of hydrogen [see Abs. 754 (1916)], has shown that some of the vibrations there considered are unstable, and has discussed methods by which the stability of the model may be ensured. One of these, which she has merely touched upon, is the introduction as kinematic relation of the condition that the moment of momentum of each electron must remain constant. The present author, noting that the conditions are expressible in equations which recall those between infinitesimal changes of the coordinates in a non-holonomic system, obtains the equation of motion, in accordance with the usual treatment of such systems, by introducing into the formula of d'Alembert's Principle auxiliary forces which do not come into play in any virtual displacement. It is then found that the positive angles of the electrons must remain unchanged, and hence that the auxiliary forces can be tangential only. The result of the calculations is that, while the model can be made

stable in this manner, the dispersion formulæ, both for H and He, are not in accordance with those obtained by experiment. In a note added to the English translation the author observes that, since his paper was written, C. Davisson [see Abs. 1339 (1916)] has employed the same method of making the model stable, and that his dispersion formulæ, while differing from those here obtained, are also in conflict, as their author points out, with the experimental results. The present author suggests that the discrepancies between Davisson's theoretical formulæ and his own arise from the former's having omitted to allow for the influence of conditions which, according to the present paper, must be taken into account. G. W. DE T.

363. *The Gravimetric Survey of the United States.* **W. Bowie.** (Nat. Acad. Sci., Proc. 3. pp. 171–177, March, 1917.)—The gravimetric survey of the United States really began in 1890 with the introduction of the Mendenhall half-second invariable pendulum. Previously, inaccurate pendulums were used. The Mendenhall pendulums are used to determine the difference in the intensity of gravity at two stations. The gravimetric survey is planned for an indefinite period, and there are two immediate purposes served in carrying on this work, namely: first the collection of data from which more accurate values may be obtained for the flattening of the earth and for the terms in the gravity formula; and second, to obtain values of the intensity of gravity at laboratories, such values being needed in certain physical and chemical work. Another important use to which the gravimetric survey may be put is in research into the subject of isostasy. The work done in the survey shows that, at some depth below sea-level (of the order of 100 km.) the pressure of any unit column is very nearly equal to that of any other unit column. If the assumption be made that the equalisation of pressures at the supposed depth (the depth of compensation) is perfect, then the land masses must be counterbalanced by deficiencies in density of the materials below sea-level under the topographic features. It is very probable that the pressures are practically equal for areas of the order of 10,000 square miles but not for small areas of the surface at the depth of compensation, and one of the problems in hand is to collect sufficient data to show the minimum area which may be in a high state of isostasy. Another problem investigated is the distribution horizontally and vertically of the deficiencies in mass which balance the material above sea-level. For computation purposes, the compensating deficiencies of density or mass are supposed to be uniformly distributed directly under the topographic feature from the earth's surface to the depth of compensation, while it is also assumed that the negative masses exactly equal the positive masses which are above sea-level. These conditions are found to be much nearer the truth than those based upon a rigid earth, with the topographical features held up by the strength of the earth's outer material, as also more valid than when the topographic features are ignored. The first table given shows the relation between the gravity anomalies and the topography, where anomaly means the difference between the observed and computed values of gravity at a station, and indicates that the conditions under which the isostatic or Hayford reductions were made are very close to the truth. Table II gives the relation of local-compensation anomalies and regional-compensation anomalies to topography. The best value from all geodetic data is believed to be 96 km. for the depth of compensation. A detailed discussion of the relation between the gravity anomalies and the geological formations is given and supplemented by tables for both the United States and India. From the values of gravity at 858 stations in the United States, Canada, India, and in Europe, which have been reduced by the isostatic (Hayford) method, the best gravity formula deduced is: $\gamma_0 = 978{\cdot}039\,(1 + 0{\cdot}005294 \sin^2\phi - 0{\cdot}000007 \sin^2 2\phi)$, where γ_0 is the value of gravity in dynes at sea-level, ϕ the latitude, and 978·039 the value of gravity at the equator. These investigations make it possible to compute the value of gravity with an average uncertainty in the result of about 0·020 dyne, or 1 in 50,000. H. H. Ho.

364. *Rotation as a Factor in Cosmic Evolution.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 77. pp. 186–199, Jan., 1917.)—Increasing rotation may break up a mass in two known ways: (1) (Poincaré-Darwin) The mass first flattens, then loses symmetry, becoming ellipsoidal and then pear-shaped, and finally throws off a satellite; (2) (Laplace–Roche) The mass, after flattening, sheds a ring of matter at the equator, the ring ultimately breaking up into satellites. These are shown to be very special cases of two general methods of break-up, proved to be the only possible ones. The former apparently leads to the normal binary-star formation; the latter to the spiral nebula formation. It is first shown that a mass rotating with uniform angular velocity ω about the axis of z, under the total gravitational potential V, including that of tidal forces, if present, will, when in equilibrium, satisfy the condition $\Omega = V + \frac{1}{2}\omega^2(x^2 + y^2) =$ constant, over the boundary, and that the surface $\Omega =$ constant coincides with the surface of constant density, and therefore also with the surface of constant pressure. To separate the difficulties, the author first considers the case of a compressible mass which is homogeneous, so that pressure is a function of density. It is then shown that if the potential of tidal forces and ω^2 be given, the equilibrium configurations may be classified by their boundaries, and that any given boundary configuration will permit of an infinite number of vibrations in which the internal configuration changes while the boundary does not, and that all the internal vibrations are necessarily stable. This special case is then extended by supposing the mass to be non-homogeneous, but such that the different types of matter in it are arranged in shells. All internal vibrations are then found to be stable so long as the shells do not change places, but there will be an infinite number of such configurations corresponding to different arrangements of the shells. If these may change places by convection, then the only stable configuration will be that of minimum potential energy. If the pressure change sign at any point on the boundary, the series of equilibrium configurations must end abruptly, and such can only occur at a sharp edge or needle-point (obviously the pressure cannot change sign in the interior, for it must first pass through zero), and the centrifugal and tidal forces will then outweigh gravitational forces, causing an ejection of matter. It follows that for a medium in which the density does not vanish at the boundary, the birth of a satellite can take place only through the first mechanism; the series of flattened figures of revolution gives place first to a series of pseudo-elliptical figures, after which the satellite is thrown off. For a gas either mechanism may come into play. If the breaking-up point, B, be nearer to the spherical configuration than the bifurcation point, P, at which the series loses its stability, the second mechanism will come into play, while in the converse case the figure of revolution will lose its symmetry after passing P, after which either mechanism may come into operation. The rotational theory fails to explain the genesis of the solar system in three distinct ways: (1) The present momentum of the system fixes too low a limit to the density near the edge of the primeval nebula for the matter thrown off to condense into planets. (2) The only form of rotational theory applicable to our system postulates matter being thrown off continuously and slowly, and the ejection would be too slow for condensation to occur. (3) Even if these objections were invalid, and matter had been condensed, the masses formed would have been much greater. The arguments depend on numerical estimates, but expressed in terms of upper and lower limits. In many cases these limits are wide, and in every case the limit most favourable to the rotational hypothesis has been taken. On the present evidence, therefore, the author considers that "we may say with some confidence that the rotational theory cannot explain the origin of the solar system. In general, it is seen that detached masses can be formed by rotation in two cases only: (1) When the angular momentum is much greater than in our system, a condition which appears to lead to the binary star formation. (2) When the mass is much greater than that of our system, a condition which appears likely to lead to the spiral nebula formation. G. W. DE T.

365. *Improved Methods in Hygrometry.* **A. N. Shaw.** (Roy. Soc. Canada, Trans. 10. pp. 85–92, 1916.)—A hygrometer of a type recently developed by E. K. Rideal and A. Hannah was tested and very satisfactory results obtained. In this instrument a known volume of the sample of air is drawn into the apparatus and the decrease in volume at constant pressure is determined after drying on sulphuric acid. The vapour pressure can be calculated in a few seconds from the reading of the instrument and the barometric pressure at the time. It was found that each observation required only from 2 to 4 mins. and an accuracy within about 1 % was obtained, whether the temperature and humidity were high or low.

The principle of a second type of hygrometer tested was based on the fact that certain salts will absorb water from the atmosphere in amount which is closely proportional to the vapour pressure existing at the time. A clean filter-paper moistened with a solution of P_2O_5 was suspended in a bottle from one arm of a balance. A constant stream of air was drawn through the bottle and it was found that the humidity could be determined satisfactorily from the weight of the paper. The apparatus required to be calibrated by comparison with a standard method, but this once done, the paper was found to remain without deterioration for a long time. A convenient form of the instrument can be constructed by hanging the paper from a sensitive spring balance in a tube open at both ends, the air circulation being maintained by a small pilot light in the top of the tube. The spring balance can be graduated to read in vapour pressure directly. J. S. DI.

366. *On the Size of the Particles in Deep-sea Deposits.* **S. Odén.** (Roy. Soc. Edinburgh, Proc. 36. pp. 219–236, 1915–16.)—The sediments which carpet the floor of the ocean have hitherto chiefly been subject only to biological and chemical inquiries, undertaken either in order to determine the character of their organic residues or to ascertain their chemical composition. Few have investigated the chemical constitution of deep-sea deposits, *i.e.* the number and dimensions of their particles. O. B. Bogghild, using Schöne's elutriation method, has separated four groups of particles, namely: those $> 0{\cdot}5$ mm. diam., 0·5–0·05 mm. diam., 0·05–0·02 mm. diam., and $< 0{\cdot}02$ mm. diam.; Thoulet has used a set of sieves for mechanical analysis, while Krümmel has recommended Mitscherlich's method of determining the total surface area of 1 gm. of the deposit by measuring its hygroscopic power instead of by weighing the different fractions as in earlier

investigations. An ideal characterisation, however, cannot be attained by dividing the sample into a smaller or greater number of groups of various sizes, or by determining their hygroscopic power or total surface, but only by obtaining a continuous distribution-curve of the well-known Maxwellian type, viz., by plotting a variable representing in some way the weight or number of the individual particles against another variable representing their linear dimensions. The present investigation was undertaken by the author to solve this problem, and especially with the intention of finding a successful mechanical analysis of the medium-sized and the finest particles contained in the deep-sea collection of the late J. Murray, and also for the study of certain Continental soils. A theoretical discussion is first given of a new method by which the rate of sedimentation from an aqueous suspension is investigated, this being a function of the size of the particles in the sample, *i.e.* a function of their distribution. The weight of sediment which settles down on a certain bottom area during unit time gives a quantitative measure which can be plotted as a precipitation- or accumulation-curve, from which the distribution-curve may be calculated by a mathematical analysis. Aqueous suspensions of bottom-sediments are coarse disperse systems for which Svedberg has shown how the distribution in size can be measured either from the different rates at which a number of particles sink in suspension or from the amplitudes of their Brownian motion. The former method fails with the bottom samples, because a considerable part of their particles sink much too rapidly for direct measurements. By simple reasoning, verified by experiment, the author has found that the rate of accumulation is a linear function both of the total number of particles and of the depth of the liquid. The experimental arrangements are next outlined. These consist in weighing from time to time, on a special balance, the amount of sediment accumulated on a circular disc suspended from the balance near the bottom of a vessel containing an aqueous suspension of the sample. Two illustrative figures of the apparatus are given. The mathematical analysis of the accumulation-curves next follows. The last section of the paper is devoted to a discussion of the results. While the author thinks it premature to draw any definite conclusions of a general character from the distribution-curves [*i.e.* curves showing how the amount of particles of a certain size varies with the latter quantity], yet one fact stands out, namely, a surprising lack of very fine particles in the deposits from the greatest depths, just where we would *a priori* expect the deposits to be relatively richest in very fine particles. Possibly this striking phenomenon can be explained as due to an agglomeration to larger units of the finest particles under the enormous pressure at these depths. Another explanation might be found in a subsequent solution of the very finest particles, also furthered by the exceedingly high pressure.

Three tables and three plates of curves add to the value of the paper.

H. H. Ho.

367. *Mathematical Note on the Fall of Small Particles through Liquid Columns.* **C. G. Knott.** (Roy. Soc. Edinburgh, Proc. 36. pp. 237–239, 1915–16.)—The present note gives in a simpler form the essence of Odén's mathematical discussion of the fall of small particles through a column of liquid [see preceding Abs.]. It has the further advantage of solving the problem without taking account explicitly or implicitly of Stokes' law as to the relation connecting the time of fall with the size, form, and density of the particles considered. The application of Stokes' formula gives what

Odén calls the "effective radius," and this may be regarded as affording a good approximation to the size of particles which are of spheroidal or cuboidal form. Should the particles, however, be of a flat, flaky form, it is doubtful if the "effective radius" calculated according to Stokes' law can be regarded as even a first approximation. Flaky particles will probably descend in zigzag courses in varying positions with fluctuating speed. It is possible that they might be set in rotation like thin slips of paper in their whirling, oblique fall through air. The distribution-curve obtained in the way described would certainly discriminate among sets of particles with different terminal velocities. H. H. Ho.

368. *A Theory of Terrestrial Volcanoes and the Geography of the Moon.* **S. Meunier.** (Washington Acad. Sci., J. 6. pp. 637–649, Nov. 19, 1916.)—According to the hypothesis put forward by the author, eruption results from the collaboration of two processes, seemingly quite unrelated: (1) The *progressive penetration of water* and other volatile substances to a depth within the earth's crust which is strictly dependent at every instant on the degree of spontaneous cooling. (2) The *tangential compression of the rocks*, due to the contraction of the nucleus and also to the tendency of the crust to founder into deeper and deeper regions where the horizontal space grows narrower and narrower. Thus the crust of our planet forms a kind of a weaver's loom, producing the volcanic tissue, the *warp* being represented by the descending network of threads of water, while the *woof* is represented by the tangential network of heated material, due to the orogenic superposition of intrusive masses over water-soaked sediments.

The new theory is stated to harmonise with the best-established facts of geodynamics. L. H. W.

369. *The Ochil Earthquakes of the Years* 1900–1914. **C. Davison.** (Roy. Soc. Edinburgh, Proc. 36. pp. 256–287, 1915–1916.)—The observations are set forth at length and are then discussed. No short abstract is possible. L. H. W.

370. *New Canadian Observatory at Victoria, B.C.* **C. A. Chant.** (Nature, 98. pp. 472–474, Feb. 15, 1917.)—In an illustrated article the author describes the instalment of the new Canadian Observatory recently erected on Saanich Hill (altitude 732 ft.), near Victoria, B.C. The dome, 66 ft. in diam., has double walls of sheet iron, with openings at the foot of the walls and louvres at the top of the dome. Being entirely of metal, the building quickly assumes the temperature of the surrounding air, which circulates freely between the double walls. The telescope, a reflector of 72 in. aperture, is mounted on a massive polar axis of the English type with supports at each end. All the movements of telescope and dome are operated by electric motors. C. P. B.

371. *Uprush of Gases in Solar Prominences.* **A. A. Buss.** (Observatory, No. 510. pp. 97–100, Feb., 1917.)—The author states his view as to the matter constituting solar prominences being actually transported from the solar surface to the upper regions of the atmosphere, in preference to the view that they may be due to indirect luminosity on matter permanently diffused through the outer regions. C. P. B.

372. *Aurora, Magnetic Storm, and Sunspot of* 1917 *January* 4. **A. L. Cortie.** (Nature, 98. pp. 446–447, Feb. 8, 1917.)—A description is given of the brilliant aurora of 1917 Jan. 4, as observed at Carlisle, and details of the variations in the magnetic elements during the progress of the accompanying storm. The greatest range in declination was 57′, in horizontal force 50′, and in vertical force 52′, where in force $1' = 4{\cdot}6\gamma$. Epochs of lesser displays of auroral activity were also marked by rapid oscillations in all three magnetic elements. Several spots were visible on the sun at the time, one large one being about 18° to the west of the central meridian at the time of the magnetic storm, and the following days were marked by solar activity resulting in the formation of several groups of small spots. C. P. B.

373. *Densities of Visual Binary Stars.* **E. Öpik.** (Russian Astronom. Soc., Publ. No. 8. p. 49, 1915. Astrophys. J. 44. pp. 292–302, Dec., 1916.)—Working on the assumption that the density of a visual binary can be determined if the surface brightness of the components is known, formulæ are developed for the computation from available observational data, and tables are given showing the results for about forty systems. It is seen that the densities cover a wide range, but there are a great number of binaries approaching the solar density. From this point of view the visual binaries differ from the Algol variables, which generally give low densities, and it seems probable that the visual systems approach more the mean conditions of the stellar universe. The eclipsing variables are known to be exceptional to the general rule, in that their luminosity is much higher than the average, the stars of early spectral type prevail amongst them, and numerically they represent only a small portion of all the stars. In the case of one star, O_2 Eridani, the formulæ do not seem to apply, and it is thought the system may be a pair of very rarefied nebulæ. C. P. B.

374. *Variations in Spectral Type of Cepheid Variables.* **H. Shapley.** Mt. Wilson Solar Observatory, Contrib. No. 124. (Astrophys. J. 44. pp. 273–291, Dec., 1916.)—From a study of the spectra of twenty Cepheid variables it is found that distinct changes in spectral type, accompanying regularly the periodic variations in light and apparent velocity, constitute one of the general properties of this type of star. A list is given of all Cepheids known to exhibit definite variation of spectral type, with a diagram of the light-curve with the corresponding spectrum type at each stage of the variations as determined from spectra photographed at the Mount Wilson Observatory. The spectrum variations extend from B_8 to G_5. [See Abs. 1217 (1916).]
C. P. B.

375. *Parallax of Three Southern Binary Systems.* **J. Voûte.** (Roy. Astron. Soc., M.N. 77. pp. 152–154, Dec., 1916.)—The measurements for the determination of these orbits were made on photographs taken with the Cape of Good Hope Astrographic refractor during 1914, 1915, and 1916; on each plate there are records at two consecutive epochs of maximum parallactic factor. C. P. B.

376. *Choice of Origin for Galactic Coordinates.* **C. D. Perrine.** (Roy. Astron. Soc., M.N. 77. pp. 151–152, Dec., 1916.)—The question is raised whether there is not a more convenient origin for galactic coordinates than the solar apex, which, according to modern work, has different values according to the class of stars used in its determination. The author suggests as origin the southern end of the so-called ellipsoidal axis, which is practically in the plane of the Milky Way. The position for 1900 would be $\alpha = 274°$; $\delta = -12°$. C. P. B.

LIGHT.

377. *Quasi-etalon Fabry-Perot Interferometer.* **H. Nagaoka.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 49–54, Feb., 1917.)—With Fabry-Perot interferometers there is always some difficulty in adjusting the plates to parallelism, and in the instruments as made by Hilger the arrangements for obtaining parallelism, though very delicate, are often liable to changes, which gradually creep in when the observations are extended over several days. In most laboratory experiments, the essential requirement is the swift adjustment of the mirrors to parallelism, which should not be easily deranged in the course of a few days, but be unaffected by the slight external disturbances to which a laboratory is constantly exposed. In the form of interferometer recently constructed by the author a hollow cylinder of invar is used, with three small projecting pieces on each end. The mirrors are chamfered off at the edges so as to form cones of very obtuse angle, and these conical portions rest on the projections. The mirrors are held down with three springs, provided with ebonite knobs coming just over the projections on the ends of the cylinder, and the pressure exerted by these springs is adjusted so that the mirrors can be moved about with moderate ease.

The essential part of the arrangement consists of a device for giving one of the mirrors minute displacements nearly parallel to its plane, by means of three screws (of ¼ mm. pitch) placed in the spaces between the springs. The screws end in ebonite knobs with hemispherical ends. The mirrors are roughly adjusted to parallelism by observing the filaments of a glow-lamp, the final adjustment being made with the screws, using the green light of mercury. After adjustment the screws are turned back free from the mirror, and the interferometer can then be gently transported without appreciable change in the parallelism of the mirrors. For measuring the length of the etalon, light from a cadmium or mercury lamp is used, and from the interference fringes obtained with the different wave-lengths the exact length can be determined, if the approximate length is already known. It is pointed out that in its new form the interferometer can be readily used for measurements of expansion coefficients, and possibly as an interferential galvanometer, a heating coil being introduced in the latter case between the mirrors. A. W.

378. *Simple Range-finder and Clinometer.* **C. R. Young.** (Eng. News, 76. pp. 1183–1184, Dec. 21, 1916.)—A simple instrument for roughly determining distances, which has been used successfully for military reconnaissance surveys and field sketching. It is based on the fact that the heights of familiar objects in the landscape, *e.g.* houses, telephone poles, doors, animals, men, can frequently be judged from experience, and from these the ranges or distances are easily determined. A rectangular piece of opaque white celluloid, 8 × 6 in., is furnished with a scale on one edge, and has a cord attached whose length, 25 in., is equal to 1000 divisions of this scale. The card is held vertically at arm's length, the cord kept taut with the free end next the eye, and the number of scale divisions (y) required to cover the object sighted is read off. If H be the true height, y the apparent height of the object, x the range, and c the length of the cord, obviously $xy = c\mathrm{H}$, which is the equation of a rectangular hyperbola referred to the asymptotes. The body of the card is covered by a cross-ruled diagram with a series of fifty hyperbola arcs, corresponding to fifty values of the estimated height H, and having as common asymptotes two edges of the diagram. Selecting the proper hyperbola, the range x corresponding to any observed apparent height y can be read off on a scale along an asymptote. The scale of y on the diagram is four times greater than on the edge scale used for observation. The device may also be used to measure the height of an object whose distance is known. The reverse side of the card has a table of dimensions of common objects, and also a scale of angular divisions, so that by attaching a plumb-bob to the cord the instrument can be used as a clinometer.

A. E.

379. *New Apparatus Shown at the Optical Society's Exhibition.* (Engineering, 103. pp. 60–61, Jan. 19, 1917.)

Simple Testing Apparatus for Signalling Mirrors. (Messrs. T. H. Ball.)—The mirror is placed horizontally on a table turned by hand; above the table is an illuminated screen, on which straight and circular lines are marked; a good mirror shows the reflection of a line single and regular, a poor mirror gives a distorted and double (from front and back of mirror) image.

Apparatus for measuring Curvature of Test Plates, Grinding Tools, etc. (S. D. Chalmers, Northampton Institute.)—A measuring microscope for determining high curvature carries a special target consisting of two parallel black lines, about 200 mm. apart; first the one and then the other line is sharply focused, and the lens is adjusted until the line becomes central in the field. In an apparatus for measuring difference of curvature of pairs of test plates, and determining the curvature of almost flat plates (radius over 500 mm.) by means of sodium D-light rings, the test plate is placed on a plane plate with the point of contact on the axis of the microscope, which is then focused on the system of interference rings, and the diameters of some rings are measured, usually the 1st, 18th, and 37th. The microscope itself should be moved horizontally, rather than the stage, lest the lens prisms should rock on one another. Apparatus were also shown for measuring prism angles, and pyramidal error due to a face not being quite parallel to the opposite edge.

Mica Wave-plate for detecting Double Refraction in Glass. (Messrs. Chance Brothers.)—The wave plate, which consists of several laminæ of mica cemented between glass plates, is used to detect double refraction in glass in the same way that it is detected in rock slides. The plate thickness is such as to give, with sodium D-light, between crossed nicols the purple of the first order. Double refraction would change that purple. When the path-difference in the plate amounts to nearly half a wave-length of yellow light, white patches produced by double refraction will be seen on badly cooled glass. This test is very severe. When the glass is partly unpolished, however, cedar-wood oil should be rubbed on the rough surfaces, lest the effects of diffused light should be mistaken for the white patches referred to. The light should be nearly parallel.

Method of finding the Refractive Index of a Liquid by means of Two Equal Prisms. (R. S. Clay, Northern Polytechnic.)—Two equal right-angled isosceles prisms of the same index—which must be higher than the index of the liquid—are placed so as to form a cube, with the hypotenuse faces in contact, and the liquid as a film between them. Light falls upon one prism, and a telescope directed at the other prism is turned until the critical angle is reached at which light is unable to pass from the first prism into the liquid. The process can be repeated with the table turned through 180°, so that the other sides of the prisms are next the light. Clay's method of finding the index of a transparent solid has been described before [Abs. 121 (1917)].

Apparatus for measuring the Magnifying Power, and the Angle between the Axes of Binoculars. (R. S. Clay.)—The apparatus consists of lamp, collimator with scale, lateral slide to carry the binoculars under test, and telescope with scale. In the absence of the binocular the collimator and telescope scales coincide. When either component of the binocular is interposed, the scales should appear superposed, but of different length, thus indicating the magnification. If the optic axes of the two components are parallel, the appearance should remain the same whichever of the two is slid into position.

Adaptation of the Michelson Interferometer to finishing of Prisms, Lenses, and Combinations. (Messrs. Adam Hilger, Ltd.)—This apparatus is for the use of the workmen. Description is not desired by the firm at present.

Weathering Test for Glass. (H. Jackson, King's College.)—The prism to be tested is subjected to the action of steam under pressure for three or more hours in an autoclave. If after this treatment it looks like a piece of ice with snow crystals adhering, then the glass would show considerable weathering with ordinary use.

Test for Parallax in Telescopic Sights for Rifles. (Optical Department of the Ministry of Munitions.)—The method makes use of an artificial eye, which is moved by a slide. The eye of the observer has not to be moved from side to side in the usual unsatisfactory way. The telescope is provided with a vertical pointer and two cross-lines, and the pointer should keep its position with regard to the cross when the pupil is shifted.

Field-glass Tester for determining Magnifying and Illuminating Power and Field of View of Binoculars. (C. V. Drysdale. Exhibited by Messrs. Tinsley and Co.)—The chief parts (all mounted on a slide) are a camera serving as artificial eye, table for binocular in front of it, collimator, and lamp L; there is also a small auxiliary lamp L′, in series with L, attached to the camera. A scale marked on the collimator screen is focused to coincide with an equal scale on the camera screen or "retina." When the binocular is put in position the image of the collimator scale is magnified by an amount which can be read off. The upper part of the camera is cut off by a slanting partition, and illuminated by the small lamp L′ through a window in front. L′ is slid in its tube till the parabolic light spot from L′ is equal in brightness to the circular spot from L. When the binocular is interposed the main field will be darkened; a sliding shutter is then drawn across the window till equality of illumination is restored. A pointer attached to the window indicates the illumination of the field in percentages of that of the object as seen with the fully open pupil, diam. 5 mm., this being the aperture of the camera lens.

Binocular Parallelism Tester. (C. V. Drysdale.)—Two collimators are fixed vertically side by side, each having an osram lamp fitted into its lower end. The two collimator beams are brought to focus by a lens of 1 m. focal length; a bright disc is then seen on a horizontal screen above. When the binocular pair is placed immediately above the collimator pair, the bright disc will simply appear enlarged if the axes are parallel; if they are not parallel the bright disc will appear divided into four sectors.

Micrometers for measuring Prism Angles before Polishing. (Uni-Bifocal Co.)—The prism, supported by four rounded studs or balls, rests between steel plates at an angle of 90° or 45° to one another. Micrometer screws pass through the plates, or through an arc attached. By shifting the prism parallel to the common edge of two plates, measurements can be made at different spots of the prism.

Testing the Definition of a Prism. (Uni-Bifocal Co.)—Light from a distant point source is reflected from a face of the prism into a telescope. The point image on the screen should turn into a square when the telescope is pulled out of focus, but if the definition be faulty, or if the prism has a pyramidal error, the square will be distorted.

Workshop Prism-testing Machine. (Messrs. W. Watson and Sons.)—The horizontal face of the prism is placed on a five-point bearing (steel balls), and the vertical face bears against the lower end of a magnifying lever, the upper end of which moves under spring pressure in the field of a microscope reading to 20″. The machine is standardized with the aid of a glass block having four well-polished faces; the mean of the four angles measured must, of course, be a right angle.

Determining Curvature of Polished Surfaces by the Microscope. (Messrs. W. Watson and Sons.)—The apparatus described is based upon the principle that there are two cases in which an object and its image in a reflecting surface coincide, viz. when the object is in contact with the surface, and when the object is at the centre of curvature. The object is a lamp, its image being reflected down the microscope by a mirror at 45°, and the distance is measured through which the instrument has to be focused to pass from one of the positions to the other. This can be done within 0·1 mm., even for small irregular fragments of polished surfaces.

Naked Eye Test for Angles of Right-angled Prisms. (Conrady. Messrs. Watson and Sons.)—In a right-angled prism the angle between the incident ray and the twice-reflected ray is constant only for certain angles, especially in the case of grazing incidences. If the prism is held so that the reflected image of a tungsten lamp is seen for nearly grazing incidence, and the prism turned a little to right or left, then the width of the lamp, *i.e.* the distance between the metal filaments, will appear to change if the angles differ very slightly from their correct values. A. E.

380. *Refractivity determined by Displacement Interferometry.* **C. Barus.** (Nat. Acad. Sci., Proc. 3. pp. 117–122, Feb., 1917.)—In continuation of previous work on the use of curvilinear compensators in connection with the displacement interferometer [Abs. 1522 (1915)] the author has developed a method of determining the refractivity of lenses, etc., by immersion in a solution of mercury iodide. It is essential for accuracy that the walls of the trough in which the liquid is contained be optically plane-parallel. The trough is introduced in the path of one of the beams in a displacement interferometer, and from the amount of motion of one of the mirrors required to re-centre the interference pattern, the index of refraction of the liquid can be determined to the fourth place of decimals. By adjusting the concentration of the solution so that the introduced lens produces no effect, the refractivity of the lens can be found with equal accuracy. But this alteration of concentration is not essential, for, using lenses of lower power (1 or 2 dioptrics) it was found that the elliptical interference pattern remained strong and clear if the solution refracts more strongly than the submerged glass, the latter being well centred with regard to the beam of light. To perfect the method a solution must be found whose dispersion constants are not so great, compared with glass, as the mercury iodide solution. A. W.

381. *Visual Diffusivity.* **H. E. Ives.** (Phil. Mag. 33. pp. 18–33, Jan., 1917.)—In a previous paper by the author and F. E. Kingsbury the theory was developed that the transmission of impressions from the retina to the brain takes place in accordance with the laws of conduction [Abs. 320

(1916)]. Experiences with the flicker photometer find explanation in the assumption that the stimulus is transmitted through a layer of matter having a coefficient of diffusivity which varies with different colours, and with the intensity of the stimulus. The diffusivity of coloured light is a rectilinear function of the logarithm of the stimulus intensity.

The author describes some experiments with rotating discs which confirm the theory. The apparatus consists of two metal discs, both mounted on the same shaft but one being of smaller diameter than the other. Radial slots are cut in both discs near the periphery; the front disc can be moved in position relatively to the other, the angular displacement between the two slots being measurable. Behind the slits is placed a translucent illuminated surface such as opal glass. It is then found that if one slot is covered with neutral glass so as to appear somewhat darker than the other, the darker slot appears to be displaced behind the brighter one during rotation of the discs. The effect is less pronounced at a high illumination than at a fairly low intensity. If blue, green, and red slits are used the same effect is observed, the green slot being displaced backwards with regard to the red, and the blue more so. This effect also becomes much less evident at very high illuminations. In addition to the displacement of the coloured slots, there is an after-image which takes the form of a phantom slot following the coloured slot at a given interval, depending on the intensity. This after-image does not occur with red light. All these phenomena are stated to be in harmony with the author's theory, which he further illustrates by a diagram comparing the progress of sensation following exposure of the eye to light, with the electrical transmission of a brief stimulus by a line containing inductance and capacity. J. S. D.

382. *Fixed System of Grating Interference Bands.* **C. K. V. Row.** (Nature, 99. pp. 63–64, March 22, 1917.)—When white light is reflected from a plane replica-film grating, backed by a parallel silvered surface separated by a film of air, a remarkable system of interference bands make their appearance. This system, when examined by a spectrometer with a fixed collimator, remains absolutely fixed in the field of view of the telescope as the grating is rotated. The rotation has the effect only of moving the spectrum to and fro across the field of view without in the least altering the position of the dark fringes. The fringes appear to be due to the interference between two portions of light arising out of the single beam incident on the grating, one of them being reflected at the silvered surface and then diffracted out by the grating element which it meets, and the other being diffracted into the air-space by the same grating element and then reflected out by the silvered surface. Simple theory shows that the fixity of the fringes can be satisfactorily accounted for in this way. A. W.

383. *Photometry of Radio-active Luminous Compounds.* **N. E. Dorsey.** (Washington Acad. Sci., J. 7. pp. 1–6, Jan. 4, 1917. Contribution from the Bureau of Standards.)—Describes a photometer set up at the Bureau for measuring the surface brightness of samples of self-luminous compounds. This apparatus consists of a photometer box provided at one end with a milk-glass window, the brightness of which can be varied in a known manner by moving a comparison lamp inside the box. The sample of compound to be measured is contained in a thin-walled glass tube blackened over two-thirds of its circumference and is supported in front of the window

with the blackened part of the tube turned towards the glass. The brightness of the window is then varied until the luminosity of the milk-glass appears to be the same as that of the material. The precautions necessary in making photometric measurements at the low intensities experienced (order of 10 microlamberts, *i.e.* 0·01 equivalent candle-ft.) are described in detail. J. W. T. W.

384. *Photometer for measuring Hardness of X-rays.* **H. Seeman.** (Phys. Zeits. 17. pp. 622–626, Dec. 15, 1916.)—A short abstract is not possible. The original should be consulted. A. B. W.

385. *Limitations of Fermat's Principle.* **K. Uller.** (Phys. Zeits. 18. pp. 35–41, Jan. 15, 1917.)—This paper, which is entirely mathematical, consists of a criticism of the hitherto accepted theory of the refraction and extinction of waves in inhomogeneous substances. L. H. W.

386. *Recent Progress in Spectroscopy.* **E. P. Lewis.** (Science, 44. pp. 899–912, Dec. 29, 1916. Paper read before the Am. Assoc. for Advancement of Science, Dec., 1916.)

387. *Diffraction of Light or Sound Waves.* **U. Crudeli.** (N. Cimento, 11. pp. 277–296, May–June, 1916.)—A purely mathematical treatment. L. H. W.

388. *Formulæ for Spectral Series.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 20–41, Feb., 1917.)—Bohr has shown [Abs. 1930 (1913)] that the Balmer series formula can be derived from the quantum theory. In the present paper the author deduces similarly the general series formula:

$$\frac{1}{\lambda_0} = \mathrm{A} - \frac{a}{(n+\mu)^2\left\{1 + a(\mathrm{A} - 1/\lambda_0) + b(\mathrm{A} - 1/\lambda_0)^{3/2}\right\}} - \frac{a\sigma}{(n+\mu)^4},$$

where A, μ, a, and b are constants for one and the same series. The formula is then applied to the various series of magnesium, and it is shown to yield results in excellent agreement with the observed values. A. W.

389. *Infra-red Spectrum and Maxwell's Theory.* **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Ber. 4. pp. 47–63, 1917.)—Gives a *résumé* of and discusses work on the infra-red spectral region in relation to the electromagnetic theory of light. Does not admit of brief abstract. A. W.

390. *Limit of Spectrum in the Ultra-violet.* **T Lyman.** (Science, 45. p. 187, Feb. 23, 1917.)—Describes briefly a continuation of previous work [Abs. 778 (1916)]. The general design of the spectroscope has not been changed, but the 100-cm. grating has been replaced by one of 50 cm. radius, thus halving the light-path and considerably reducing the volume to be exhausted. The design of the quartz discharge tube has been altered so that the end of the capillary can be brought much nearer the slit of the spectroscope, and the p.d. of the transformer has been considerably increased. Using helium at one or two mm. pressure, the net result of these changes is that the spectrum has certainly been extended from 600 to the neighbourhood of 510 Å.U. A trace of a line was found on one negative near 450 Å.U., but it is too faint to afford trustworthy evidence. Wood's miniature arc *in vacuo* and a variety of vacuum spark arrangements have been tried, but none of these sources appear to yield lines in the most refrangible region. A. W.

391. *Periodic System of Elements in Elementary Spectral Analysis.* **V. Kutter.** (Phys. Zeits. 18. pp. 16–17, Jan. 1, 1917.)—Nernst has shown a relationship to exist between the melting-point of the pure metals and their atomic weights. Following up this idea and taking account of the various ways of causing the elements to emit a spectrum, the author has arranged the elements in various groups. If the degree of volatility of the various elements is plotted against their atomic weights it is seen that the points obtained lie on a curve, which is reproduced in the original article. [*Erratum.* Ibid., p. 67, Feb. 1, 1917.] A. W.

392. *High-vacuum Spectra of Gases.* **D. N. Mallik** and **A. B. Das.** (Phil. Mag. 33. pp. 253–256, March, 1917.)—Owing to the simpler molecular conditions in gases at very low pressures it seems reasonable to expect a simpler spectrum than at moderately high pressures. A magnetic field, again, is more likely to effect a change in the spectrum than under ordinary conditions. Experiments, so far as they have gone, tend to confirm these conclusions. Photographs of the spectrum of air show no change when the pressure is varied from 33 mm. down to 0·01 mm. in a tube of length 14·5 cm., an induction coil being used giving a spark-length of 29 mm. in air at atmospheric pressure. At about 0·01 mm. pressure, however, the character of the spectrum seems suddenly to change, giving a partially simplified spectrum, while a simple spectrum of 4 lines, which are found in the original spectrum, is obtained when the pressure is about 0·001 mm. On introducing the magnetic field there seems to be a small shift, which, however, requires further examination. If this shift is not fortuitous, it ought to prove of great theoretic interest. Experiments with hydrogen, so far as they have gone, seem to give similar results, but further work is necessary to confirm them. A. W.

393. *Regularity in the Distribution of the Satellites of Spectrum Lines.* **H. Nagaoka.** (Phys. Soc., Proc. 39. pp. 91–118; Disc., 119, Feb., 1917.)—Describes a further development of the work done by the author and Takamine on the distribution of the satellites of the mercury lines [Abs. 424 (1918)]. The apparatus employed was a Fabry-Perot interferometer crossed with an echelon or Lummer-Gehrcke plate. An account of the theory governing the interpretation of crossed spectra is given. It is shown that much of the discord between the results of various observers of these satellites is due to the unsatisfactory nature of the principal line as a datum from which to define their positions, and that if the distances be measured from one of the distinct satellites, good agreement is obtained. If these separations be expressed as differences of wave-number, instead of wave-length, a remarkable symmetry in their distribution becomes apparent. For example, among the satellites of the green line λ5461 can be found three groups of symmetrical triplets, of which the wave-number differences are in the simple ratios 1 : 3 : 12. Similar results are obtained for other lines, the principal component of λ4359 being shown for the first time to consist of a triplet, the middle component of which is relatively weak. A similarity in the distribution of the satellites exists for all the lines examined, and certain wave-number intervals are common to all. It is observed that the intervals given by $lc/3$, $mc/4$, $nc/5$, where $c = 0{\cdot}71$, and l, m, and n are whole numbers, are found among satellites of the eight lines dealt with for $l = 1$ to 4, $m = 1$ to 7, and $n = 1$ to 7. The possible origin of satellites is discussed in the light of the Zeeman and the Stark effects, the magnetic or electric fields being electronic in origin, and

many of the results are shown to be consistent with Voigt's theory of the vibrations of electrons in an isotropic, quasi-elastic, electric field. The suggested explanations can only be tentative as yet, pending further development of our knowledge of the theory of the Zeeman-effect, and the extension of J. J. Thomson's work on positive rays to a larger number of substances.

The second part of the paper consists of a mathematical investigation of terms of correction in the theory of large-sized concave gratings, which prevent the theoretical resolving power from being realised in practice. A. W.

394. *Satellites of Spectral Lines.* **R. A. Houstoun.** (Roy. Soc. Edinburgh, Proc. 36. pp. 199–208, 1915–1916.)—The purpose of the present paper is to suggest that satellites may in some cases be caused by sudden changes of amplitude or phase in an oscillator of one definite period. The explanation is interesting principally on account of the use it makes of certain well-known diffraction formulæ. One example will illustrate the method adopted. Let the oscillator emit a wave given by $\cos \beta t$ from $t=0$ to $t=l$; let it then rest from $t=l$ to $t=l+k$, and again emit the wave given by $\cos \beta t$ from $t=l+k$ to $t=2l+k$; there are thus two periods of activity of equal duration separated by a period of rest. Consideration of the Fourier integral for the wave shows that the energy contained between the periods specified by α and $\alpha+\delta\alpha$ is $4\sin^2\frac{1}{2}(\alpha-\beta)l \,.\, \cos^2\frac{1}{2}(\alpha-\beta)(l+k)/\pi(\alpha-\beta)^2$. The factor $4\sin^2\frac{1}{2}(\alpha-\beta)l/\pi(\alpha-\beta)^2$ has a maximum at $\alpha=\beta$, whence it descends to minima at $(\alpha-\beta)l=\pm 2\pi$. The other factor is zero at $(\alpha-\beta)(l+k)=\pm(2n+1)\pi$. Let $l=k$; then three of the zeros occur in the original central part of the pattern. Considering the two factors together, we see that the main part of the original line is now resolved into five components. The analysis is practically the same as that used in the calculation of Fraunhofer diffraction patterns. The case just considered corresponds to the case of two parallel slits separated by an opaque interval. To every Fraunhofer diffraction pattern there corresponds a method of starting and stopping the oscillator. The question, therefore, as to whether the structure of a certain line can be explained on the method suggested in this paper resolves itself into the question as to whether a Fraunhofer diffraction pattern can be produced having the structure of the line. This will be best solved by trial, by fixing an arrangement of slits on the table of a spectrometer so that the rays from the collimator fall on them normally, and examining the appearance seen in the telescope. A. W.

395. *Phosphorescence of Certain Sulphides.* **E. L. Nichols.** (Nat. Acad. Sci., Proc. 3. pp. 199–202, March, 1917.)—In this paper the author discusses measurements by Howe, Howes, and Hodge. In a recent paper Nichols gave evidence of the existence of more than one band in the spectra of some phosphorescent sulphides. It seemed probable that the regions of max. excitation were due to the presence of absorption bands. This hypothesis was tested by Howe, using the light from the submerged aluminium spark described by Henri. For a certain barium sulphide with lead as an active metal, the crests of the bands of excitation were at $0{\cdot}380\,\mu$ and $0{\cdot}335\,\mu$. The crests of the absorption bands are at $0{\cdot}375\,\mu$ and $0{\cdot}332\,\mu$. Similar coincidences were established in the case of Sr, Zn and Sr, Pb sulphides. Hence it seems probable that the relation is a general one corresponding to that already established in the case of the selective activity of infra-red rays upon the phosphorescence of zinc sulphide, where the max. effect was found in regions of max. absorption. Other experiments showed that the spectrum of the phosphorescent light of the Lenard and Klatt sulphides during the first few thousandths of a second after the close of excitation, contains one or more groups of overlapping bands, the crests of each group forming a spectral series having a constant frequency-interval. The decay of phosphorescence during the first few hundredths of a second after the close of excitation may be described as consisting of two processes, each showing a linear relation between $I^{-1/2}$ and the time. The first and more rapid process lasts for less than 0·01 sec. for the three sulphides studied under the intensity of excitation employed. The second process persists for 0·06 sec. or more. The phosphorescence of long duration of the sulphides under consideration is probably due to another group of bands, of comparatively feeble initial brightness, which come under observation only after the phosphorescence of short duration has vanished. [See Abs. 185 (1917).] A. W.

396. *Kathodo-luminescence Spectra of Calcium and Iron.* **A. S. King** and **[Miss] E. Carter.** (Mt. Wilson Solar Observatory Contrib. No. 125. Astrophys. J. 44. pp. 303–310, Dec., 1916.)—The method of examining spectra by excitation with kathode rays has been shown to be effective by Hertz and Lewis, and the present work was undertaken to study the peculiarities shown for certain elements having groups of lines known to show different behaviour in the ordinary sources. The spectra were photographed with the first order of a 1-metre concave grating, the scale being 1 mm. = 17 Å. The spectrum of calcium consists of lines present in the arc, but differing in relative intensity from the arc and other sources. The lines of the single-line series are strongest, followed by the lines occurring in pairs, while the triplet series are relatively faint.

In the case of iron the spectrum obtained shows the fundamental lines, which are strong in all sources of the metal spectrum. Lines characteristic of the low-temperature sources and of the spark are absent.

Bands of the positive and negative pole spectra of nitrogen were shown, the negative bands having high intensity. C. P. B.

397. *Absorption and Emission of X-rays.* **W. Schottky.** (Phys. Zeits. 17. pp. 581–583, Dec. 1, 1916.)—Observations of the laws of Kossel and Glocker [Abs. 1674 (1915) and 137 (1917)] on absorption and emission of X-rays, viz. (1) [Kossel] $a = a\lambda^b$, where "b" (a constant) varies from 2·5 to 2·9 for the various elements examined; (2) [Glocker] $k = C\lambda^4$, where k, the emission coefficient, varies as the fourth power of λ. A. B. W.

RADIO-ACTIVITY.

398. *Reflection of γ-rays by Crystals.* **P. B. Perkins.** (Science, 45. pp. 121–124, Feb. 2, 1917.)—Rutherford and Andrade [Abs. 1548 (1914)] have shown that when γ-rays fall on the faces of crystals at certain angles regular reflection takes place as in the experiments of Bragg with X-rays [Abs. 1840 (1914)]. The present paper describes a new method of attacking the same problem. A fine pencil of γ-rays is passed through a vessel containing a crystalline substance into an ionisation chamber. The crystalline structure is then destroyed (either by powdering, melting, or by dissolving in water) and any change of ionisation current measured by the balance method. The change in the ionisation gives a measure of the radiation which is reflected from the crystals at such an angle with the direction of the beam as not to enter the ionisation chamber. A table of results is included in the paper, showing the percentage of the total beam absorbed when different crystalline substances are used—but the values given are intended as qualitative indications only. A. B. W.

399. *The Genesis of Pleochroic Haloes.* **J. Joly.** (Roy. Soc., Phil. Trans. 217. pp. 51–79, Jan. 29, 1917.)—In an earlier paper on this subject it was pointed out that several features of the halo derived from the uranium family were not easily accounted for [Abs. 549 (1910)]. Further investigation was hampered by the scarcity of haloes derived from the thorium family. Recently, however, the author has secured a mica rich in thorium haloes, some appearing to be in the earlier stages of development, corresponding to the similar stage on the uranium halo. This find showed that the same course was followed in the genesis of both kinds of halo. Certain discrepancies between the observed and the theoretical dimensions of the uranium halo have been noted—this indicating that there is something anomalous, according to our existing knowledge of the ranges, in the early development of this type of halo. The nature of the nucleus of radium-emanation haloes is not determinable—it is probably zircon—but, whatever its nature, it must possess the power of absorbing or occluding the emanation or becoming a centre of radiation of the α-rays of emanation and of its subsequent products.

After a brief description of the microscopic methods used in measuring the diameters of the haloes, these methods varying according to the "density" of the halo, the author proceeds to give theoretical views as to the formation of haloes of all types. The halo is the result of the ionising effects of the α-rays proceeding from the central nucleus. Employing various well-known radio-active data with regard to the ionising power of α-rays at different parts of their range, the relative number of α-particles emitted by the successive products of a radio-active series, etc., the author explains the occurrence of the various dark discs and rings appearing on haloes of different types. These views apply particularly to the case of well-developed haloes, but observations of haloes in the earliest stages of development show a marked discordance with such views. This is true both in the case of Ur and Th haloes. By introducing the assumption that haloes partake of the properties of "reversal" or "solarisation" under certain conditions (*i.e.* analogous to photographic reversal) it seems possible to explain the observed structural features [Wood, Phil. Mag. 6. pp. 577–587 (1903)]. If it is supposed that the effect, say, of the slowest α-ray, at any particular distance from the centre, was exposed to reversal by all the faster-moving rays which might pass within effective distance thereto, an additional diminution of destructive effect outwards can be accounted for, since the several rays fall out one by one as the radius increases. The radius and "absorbing power" of the nucleus are considered as important corrections to be applied in the determination of the "ranges" in mica of the various groups of α-particles.

Detailed observations and tabulated observations are supplied for the following haloes in successive stages of development:—(*a*) Ur (4 stages of growth); (*b*) RaEm haloes; (*c*) Th haloes; (*d*) Compound Ur-Th haloes.

Various departures of the observed ranges in mica from the calculated ranges in air (using a "conversion factor" = 2075) are discussed: several suggestions are offered tentatively, but the matter is still left open.

The paper concludes with a general survey of the possible important geological and "radio-active" information which may be obtained from a study of haloes.

A plate is included showing the different types of halo in their various stages of development. A. B. W.

HEAT.

400. *Apparatus for determining Freezing-point Lowering.* **R. G. Van Name** and **W. G. Brown.** (Am. J. Sci. 43. pp. 110–114, Feb., 1917.)—The apparatus operates, like the Beckmann method, on the undercooling principle. The whole process (undercooling, inoculating, freezing, and re-melting in preparation for a new determination) is carried out in a vacuum-walled container (Dewar tube). L. H. W.

401. *Latent Heat of Steam.* **T. Carlton-Sutton.** (Roy. Soc., Proc. 93. pp. 155–176, April 2, 1917.)—The latent heat of vaporisation of water at 100° C. and 1 atmo. pressure has been measured in terms of the mean calorie by means of a modified Joly steam calorimeter. A small closed glass bulb suspended from the arm of a balance is cooled to 0° C. in a mercury chilling bath. It is then raised, by means of a windlass (which forms part of the suspension), into a heat-insulated chamber at 0° C. and there weighed. The chilling bath is replaced by a steam jacket into which the bulb is subsequently lowered. By weighing the bulb in the steam the mass of water condensed on it is determined. The bulb is then opened, nearly filled with water, closed again, and the experiment repeated; so that by subtraction the condensation due to the water alone is obtained. The final data from one set of experiments were as follows:—*Apparent* condensation on empty bulb 0·36502 gm., on filled bulb 1·07425 gm., *real* difference (after applying all corrections) 0·71181 gm., mass of water in bulb 3·8360 gm., whence, at once, L = 538·89 mean cals. Another set of data, obtained with a different rate of supply of steam to steam jacket to check dryness of steam gave L = 538·86. The final mean of the two sets of experiments is given as 538·88 mean cals. Reference must be made to the paper for the full (thermodynamic) theory of the experiment, the numerous refinements and small corrections, and the discussion of limits of accuracy. It is claimed that the result is correct to 7 or 8 units in the fifth figure. D. O. W.

402. "*Stepped*" *Ignition.* **R. V. Wheeler.** (Chem. Soc., J. 111. pp. 130–138, Feb., 1917.)—During researches on the electrical ignition of gases, Thornton has observed certain discontinuities, to which he has applied the term "steps," and on which he bases a theory regarding the manner in which the ignition of inflammable mixtures of gases in general is effected. The steps were first recorded when determining the effect of change in the composition of mixtures of ethane and air on their ignition by condenser discharge sparks [see Abs. 82 (1915)]. They are also stated by Thornton to occur when ignition is by the impulsive electrical discharge, either (1) when the proportions of a combustible gas (*e.g.* methane) mixed with air are varied, the pressure being maintained constant [Abs. 700 (1916)], or (2) with a given mixture of combustible gas and air when the pressure is varied. Sastry was unable to confirm the former of the two observations respecting ignition by the impulsive electrical discharge in the case either of methane or of hydrogen. The remarkable nature of Thornton's results, and the importance of the theories to which they lead, has induced the present author to make an investigation especially for the case of mixtures of methane and air. The steps observed by Thornton, when the percentage of methane in air was varied and ignition was by the impulsive electrical discharge, were ill-defined, and are stated to have occurred only when the sparking electrodes were unclean. Their existence is therefore doubtful. Using an experimental

method apparently similar to Thornton's the author has been unable to detect any discontinuity, although the curve has been traced over a wide range repeatedly. No discontinuity was also observed with mixtures of air and hydrogen, or with any one of the gaseous paraffin hydrocarbons. In the present paper an examination is made of the more striking discontinuities recorded by Thornton when a 9·5 % mixture of methane and air was ignited at different pressures by the impulsive electrical discharge. Curves are given representing the results obtained by Thornton and the author, and, from the absence of discontinuity obtained by the latter, it would seem that the production of "stepped ignition" as recorded by Thornton requires some condition of experiment which the author has either been unable to reproduce or by some means has excluded. In consequence a detailed description of the experimental conditions is given. A mathematical analysis of the curve obtained by plotting igniting-currents as ordinates against pressures as abscissæ is given by Greenwell. He finds the curve to be remarkably smooth and suggests that it follows a definite law. On investigation the curve proves to be a hyperbola from which certain general conclusions are deduced as follows:—(1) The quantities represented by the observations of the igniting-current and the degree of compression are mutually involved. (2) The real quantities, as distinguished from the recorded quantities, may be represented by employing inclined axes parallel to the asymptotes of the hyperbola, the position of the origin remaining the same. (3) The distance, parallel to the axis OX′, between the axis OY′ and the relative asymptote represents the real value of the minimum pressure at which ignition can be obtained (under the experimental conditions) with any current. The distance, parallel to the axis OY′, between the axis OX′ and the relative asymptote represents the real value of the minimum current which can produce ignition with any degree of compression. (4) The product obtained by multiplying the real value of the pressure less the minimum pressure by the real value of the igniting current less the minimum igniting current is constant. H. H. Ho.

403. *On Adiabatic Changes of a System in Connection with the Quantum Theory.* **P. Ehrenfest.** (K. Akad. Amsterdam, Proc. 19. pp. 576-597, 1917.)—In an increasing number of physical problems the foundations of classical mechanics (and electrodynamics) are used together with the quantum hypothesis, which is in contradiction with them. It is desirable, therefore, to arrive at some general point of view from which each time the limit between the "classic" and the "quantum" region may be drawn. Wien's law has been found by an application of classic principles: the changes of the distribution of the energy over the spectrum and the work done by a reversible adiabatic compression are calculated quite according to classic electrodynamics. This law, derived without the use of quanta, stands unshaken amid the quantum theory, and so is worth consideration. The author submits the standpoint that perhaps something similar holds in more general cases, when no longer harmonic vibrations take place, but more general motions, and here the reversible adiabatic changes might be calculated by the classic method, while for other changes, such as the isothermal addition of heat, the quanta theory can be utilised. The author has already adopted this in previous papers, making use of Einstein's adiabatic hypothesis, viz., if a system is exposed to reversible adiabatic influences the theoretically "admissible" motions are transformed into such like "admissible" ones. Suppose for some class of motions the quantum hypothesis to be introduced for the first time.

In some cases the adiabatic hypothesis quite determines which special motions are "admissible," namely, in the case that the new motions can be derived from a former class of motions by a reversible adiabatic process, for which has been already fixed, those of the special motions which are "admissible" (especially, therefore, if the new motions can be obtained from harmonic motions with one degree of freedom). In other cases the adiabatic hypothesis puts, at least, limits to the arbitrary way in which otherwise the quantum hypothesis might be applied. In each such application of the adiabatic law a great part is played by the "adiabatic invariants," that is, those quantities which before the adiabatic process have the same value. Formerly there has been shown especially that for arbitrary periodic motions (of one or more degrees of freedom) there exists the adiabatic invariant $\overline{2T}/\nu$, ν being the frequency and T the mean value of the kinetic energy with respect to the time. The purpose of the considerations in this paper is : (1) To formulate the adiabatic law as sharply as possible, at the same time indicating where this sharpness is failing, especially with respect to non-periodic motions. (2) To indicate what significance must be ascribed to the "adiabatic invariants" in the quantum theory. The discussion of the above-mentioned invariant $\overline{2T}/\nu$ especially will show how it forms a link between the adiabatic hypothesis, on the one hand, and the quantum hypothesis of Planck, Debye, Bohr, and Sommerfeld on the other. (3) To point out difficulties which arise at the application of the adiabatic hypothesis so soon as the adiabatic reversible changes lead through singular motions. (4) To show at least how the adiabatic problems are connected with the statistical bases of the second law of thermodynamics. The statistical mechanical explanation Boltzmann gave of it rests on statistical foundations which are destroyed by the introduction of quanta. Since then a statistical deduction has been given of the second law for some special systems (*e.g.* for those with harmonic vibrations) but not for more general systems.

Section 1 of the paper deals with the definition of the reversible adiabatic influence on a system and on adiabatic related motions. Section 2 considers the formulation of the adiabatic hypothesis for systems with periodic or quasi-periodic motions. Section 3 treats adiabatic invariants and their application, while Section 4 deals with the particular adiabatic invariant $\overline{2T}/\nu$ and ϵ/ν especially for harmonic motions. Section 5 give a geometrical interpretation of the adiabatic $\overline{2T}/\nu$ in the (q, p) space. Section 6 derives the connection between the adiabatic hypothesis and the quantum hypotheses of Planck, Debye, etc., for systems with one degree of freedom. Section 7 shows the connection with Sommerfeld's quantum hypothesis for systems with more than one degree of freedom. Section 8 points out the connection of the adiabatic hypothesis with the statistic basis of the second law. Section 9 considers the difficulties which occur if the adiabatic reversible change gives rise to a singular motion, and then treats of non-periodic motions. In an appendix the author gives the proof that $\overline{2T}/\nu$ is an adiabatic invariant for a system with periodic motions, and then discusses motions in an isotropic elastic field of force according to the quantum hypothesis of Sommerfeld, concluding by a comparison with Planck's formulæ.

The author trusts that the difficulties not yet surmounted may receive attention by others, and he suggests that perhaps a close investigation will show the adiabatic law not to hold in general. At all events Wien's law appears to show that in the quantum theory a special place is taken by the reversible adiabatic processes and that for them the classic foundations can be of most use.

H. H. Ho.

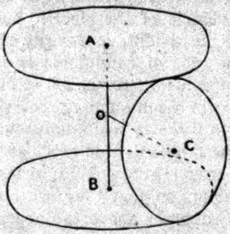
ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

404. *A Possible Function of the Ions in the Electric Conductivity of Metals.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 3. pp. 163–171, March, 1917.)—The present paper is a development of a previous suggestion concerning electric conduction in metals [see Abs. 1138 (1915)]. It rejects the free electrons within the metal as the vehicle of the electric current, and puts in their place for this function the metal ions, necessarily equally numerous with the free electrons. Briefly the idea of conduction is as follows :—At very low temperatures the atoms of a metal are packed so closely that electrons pass readily from one to another in a continuous procession through the metal, if there is an applied electric force to maintain progression in one direction. Free electrons and metal ions, if ionisation exists at the lowest temperatures, need not be called into action here. With rising temperature the heat vibrations separate the atoms so that they are not always in conductive contact, and not very many degrees above the absolute zero they are, on the average, so far apart that conductive contact between them is exceptional In this state of things an electron will not, in fact, pass from one metal particle to another, even when they are in the closest contact of a collision, unless one of those particles is an atom and the other an ion. Two figures are given to illustrate the fundamental difference, from the point of view of conduction, between an atom-atom collision and an atom-ion collision. The author next considers the requisite number of ions per unit volume in order to maintain currents of great density, and finds that the degree of ionisation may be low, as compared with the number of atoms. For the case of copper at 300° C. abs. the number of ions required to maintain a current of 1000 amps. per cm.^{2} appears to be about 1 for every 170 atoms—a number which cannot be objected to on the ground that it would make the specific heat of the metal too large. Following this comes an investigation as to whether the conductive action of the ions conforms to Ohm's law. The mere fact that so small a portion of all the atom-ion collisions need be decisively affected by the potential gradient in order to maintain large currents raises a very strong presumption in favour of the proposition that the number of cases so affected will be proportional to the steepness of this potential gradient. The last question to be considered is the temperature relations of conductivity if due to ions. Here the author seeks to account for the temperature relations of conductivity by combining with his previous theory the hypothesis of an atomic vibration consisting of a simple harmonic motion prematurely ended by collision of atom with atom or with an ion. This attempt, though not entirely successful, seemed not altogether hopeless until the experiments of Bridgman showed the atoms to be far less rigid than the kind of vibration in question required them to be. The author now admits it to be probable that he has greatly underestimated the range of temperature through which the normal atoms may, in spite of the heat vibrations, be regarded as remaining in conductive contact with each other, and that, accordingly, the important function assigned by the author's theory to the ions may not belong to them, except perhaps at relatively high temperatures or in the liquid state of the metals. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

405. *Mechanical Analogy of Coupled Oscillating Circuits.* **J. B. Pomey.** (Rev. Gén. d'Él. 1. pp. 83–84, Jan. 20, 1917.)—It is customary to use mechanical analogies to illustrate the interaction of electrical coupled circuits and to use for this purpose either mechanically coupled oscillating pendulums or magetically coupled oscillating magnets. These models do not give exact analogies because their kinetic energy is proportional to the speed, whereas the kinetic energy of the currents is proportional to the square of speeds. A mechanical model that leads to equations of motion exactly similar to those in the case of electric circuits may be constructed of three discs, A, B, and C. A and B are mounted on the same shaft like wheels and held in given positions by spiral springs. C runs on both of the discs A and B and is mounted on a shaft OC that can rotate about O. The equations for the motion of this system are shown to be exactly similar to the equations for electric circuits. A. J. M.



406. *Influence of Time Element on Resistance of a Rectifying Contact.* **D. Owen.** (Phys. Soc., Proc. 29. pp. 33–47; Disc., 47–48, Dec., 1916. Electrician, 78. pp. 278–280, Dec. 1, 1916. Abstract.)—The original pages should be studied in conjunction with the curves of results there given. Here it is only possible to reproduce the author's summary as follows:—The resistance at a solid rectifying contact, and consequently the exact shape of the resistance characteristic, depends upon the time for which the testing current is allowed to flow. A series of characteristics are given corresponding to durations of contact extending over the range one forty-thousandth of a second to 30 secs.

The following conclusions are drawn:—(1) The variation of resistance with voltage may be attributed entirely to thermal effects. (2) The characteristic obtained by applying the testing voltage for 1/100 sec. is, at moderate voltages, materially the same as that which would be found at the expiry of a period of the order of a millionth of a second. (3) The sensibility of a wireless receiving circuit (in which the rectifying contact is used) does not differ very appreciably from that deduced from a slow-period characteristic. (4) An important fraction of the contact-resistance resides in a stratum of molecular thickness at the interface of the two elements of the contact; it is in this region alone that rectifying action at very high frequencies is effected. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

407. *Absence of Thermal Hysteresis in the Copper-Constantan Thermo-element between* 30° *and* 100° *C.* **T. W. Richards** and **H. W. Richter.** (Am. Chem. Soc., J. 39. pp. 231–235, Feb., 1917.)—Experiments were made to test whether or not the copper-constantan alloy suffers any marked shift of thermoelectric effect on being subjected to rapid changes of temperature.

A twelve-junction thermo-element was tested as follows :—Two constant-temperature baths were prepared—one for each arm of the thermo-element. One of these baths was an enclosed and air-jacketed calorimeter submerged in a thermostat kept at about 28·3°, constant to at least 0·0003 deg. : while the other bath consisted of sodium sulphate at its transition temperature (32·384°) also air-jacketed in a thermostat ; the constancy of this temperature was at least 0·001 deg. The copper-constantan multiple thermo-element was placed in these baths and allowed to remain for some minutes, during which time its e.m.f. was measured and found to be very constant. It was then removed, and one arm was placed in boiling water. At the end of 5 mins. the instrument was allowed to cool and replaced in the baths.

In a most carefully conducted trial there was no perceptible alteration from the original e.m.f. The value found was 1·8988(± 0·0001) millivolts before and after treatment. So that after changing the temperature over 70 degrees back and forth within 10 mins., the thermoelectric effect was unchanged within the limits of accuracy of the measurement.

The authors point out the value of the thermo-element for calorimetric work. E. G.

408. *Effect of Light on Contact Potential.* **E. H. Kennard** and **E. O. Dieterich.** (Phys. Rev. 9. pp. 58–63, Jan., 1917.)—Experiments were made on selenium and cuprous oxide with a view of finding a change in the contact potential against copper attributable to ionisation on illumination. A condenser method and an ionisation method (with polonium) were employed for determining contact potentials. The contact potential of selenium changes on illumination by an amount exceeding a millivolt for 0·01 candle-ft. There is a tendency towards saturation at a value of about — 0·1 volt under strong illumination. Attempts to produce an e.m.f. in a closed circuit containing a plate or cube of Se were unsuccessful. The contact potential of Se relative to freshly sandpapered Cu is about — 0·4 volt in the dark. A small but less certain effect was observed in a thin plate of Cu_2O. E. E. F.

409. *String Electrometer.* **R. Jaeger.** (Zeits. Instrumentenk. 37. pp. 5–18, Jan., 1917.)—Describes the application of Orlich's theory of the quadrant electrometer [see Abs. 699 (1909)] to the case of the string electrometer (i) with one electrode earthed, the thread and the other electrode being at the test voltage, (ii) with the thread and one electrode earthed, the other electrode being at test voltage, (iii) with the thread and the electrodes at different voltages. It is concluded from the results of actual measurements on an electrometer with a fine thread (about 2·3 μ diam.) that the string electrometer can be used in the same way as a quadrant electrometer, with the advantage that it has a small capacity and is readily portable. It is not, however, so suitable for use at a low voltage. J. W. T. W.

410. *A Simple String Electroscope.* **C. W. Lutz.** (Phys. Zeits. 17. pp. 619–622, Dec. 15, 1916.)—For many electrostatic measurements an instrument of the sensitiveness of the gold-leaf electroscope is sufficient.

But for many purposes this type of instrument is unsuitable. A string-electroscope is now described, the simplicity of action of which is claimed to be not inferior to the gold-leaf instrument; it possesses in addition all the advantages of the "string" principle. The string employed is a Pt-wire 2·5 μ thick and 45 mm. long, the tension being adjustable within reasonable limits. The wire and its support are insulated from the case, the other electrode (a metal edge parallel to the wire) being connected to the case and earthed.

A series of curves included in the paper indicate that the sensitiveness of the instrument increases rapidly for increasing tension of the string—the range of applied p.d. being increased correspondingly.

Tension of String.	Range of Applied Voltage.	Sensitiveness, Volt/Sec.
(*a*) Weak (0·4)	4 to 98	1·5
(*b*) Stronger (1·2)	7 to 305	4
(*c*) Still stronger (1·6)	16 to 970	17

A. B. W.

ALTERNATING CURRENTS AND MAGNETISM.

411. *Elementary Theory of Magnetism.* **J. B. Pomey.** (Rev. Gén. d'Él. 1. pp. 206–209, Feb. 10, 1917.)—The author defines magnetic field H and induction B from an experimental standpoint. By aid of vector analysis he derives an expression for the potential similar to that obtained by considering quantities $+m$ and $-m$ acting according to Coulomb's Law. Vaschy has dealt with electrical phenomena in a similar manner in his "Théorie de l'Électricité" (Baudry et Cie, 1896). L. L.

412. *Characteristics of Iron in High-frequency Magnetic Fields.* **R. Bown.** (Frank. Inst., J. 183. pp. 41–60, Jan., 1917.)—The author aims at presenting a digest of the most important papers on this subject. [J. Russell's contributions to the theory of the operation of magnetic detectors appear, however, to have been overlooked in the literature list, as well as numerous others, such as, for instance, J. A. Fleming and Coursey's paper on curves obtained with the campograph.] L. H. W.

413. *Magnetic and Mechanical Properties of Steel and Nickel.* **S. R. Williams.** (Cleveland [U.S.A.] Eng. Soc., J. pp. 183–194; Disc., 195–201, Jan., 1917.)—The Joule magnetostrictive effect is demonstrated by a photographic method by means of an apparatus in which the free end of the bar under test within a vertical solenoid is attached to a lever near the fulcrum at one end. A thread hangs from the other end of this horizontal lever, and passes round a horizontal spindle to a small hanging weight. A mirror fixed to the spindle gives the indications of change of length of the bar. The photographic method allows a set of readings to be taken in a few seconds, thus avoiding disturbances due to change of temperature. Four different types of change of length are illustrated, namely: a lengthening for all fields, as in manganese alloys; a shortening for all field strengths as in nickel; a lengthening followed by a shortening, as in steel; and a shortening followed by a lengthening, as in cobalt. The Wiedemann-effect, *i.e.* twist caused by the superposition of a circular and longitudinal field, is shown to be a special

case of the Joule-effect. The Villari reversal having been illustrated, the problem of gauging the mechanical properties of iron by means of magnetic tests is next dealt with, and the methods of McCann and Colson and of Burrows are described. In the first, the material, *e.g.* steel cable, is passed through a solenoid, and any variation of magnetic flux in the cable sets up counter or augmenting e.m.f.'s in the circuit which are recorded by instruments in series with the circuit. In the method of Burrows a narrow secondary coil is placed inside the magnetising solenoid and round the specimen, *e.g.* a steel rail. Any variation in the distribution of magnetic flux through the rail sets up e.m.f.'s in the secondary to which is connected a proper type of galvanometer. The author then goes on to describe an apparatus which may be taken out to test specimens which cannot be removed to the laboratory, *e.g.* car rails. Its principle, as in the other cases, depends on the change of flux through a coil connected to a galvanometer. The apparatus has the form of a horseshoe electromagnet with two sets of poles. The lower pair of poles is placed in contact with the specimen along which the electromagnet is moved, and mechanical defects, such as blowholes, are indicated by the deflection of a galvanometer connected to a winding on the electromagnet between the two sets of poles. The electromagnet is actuated by dry cells. In the *discussion,* it was brought out that the Burrows method was capable of detecting segregation in rails. Referring to the evidence of magnetic structure of the atom given by the four different types of magnetic change of length, the **Author** pointed out that magnetostrictive effects have not been included in accepted theories of magnetism. The largest change of length per unit of length dealt with is about one wave-length of sodium light; further, a hysteresis effect is obtained in the change of length, if the magnetising field is run up to a certain strength and then brought down to zero without discontinuity. G. E. A.

414. *Magnetic Storm of August* 22, 1916. **C. Chree.** (Roy. Soc., Proc. 93. pp. 177–187, April 2, 1917.)—While the ultimate cause of magnetic storms has been a fruitful source of speculation, detailed inquiries into the phenomena presented by individual storms have been comparatively few. This is to be regretted, as the theory cannot successfully be advanced on a firm basis unless the facts to be accounted for are thoroughly known. The storm here discussed, while of considerable intensity, appeared to be of a comparatively simple type, and therefore suitable for a detailed investigation. The records from Kew and Eskdalemuir Observatories are taken, and the departure of the magnetic elements from their normal values tabulated for a period of three hours from the sudden commencement of the storm. It appears that the phase of the oscillation in the North and West components of horizontal force differed by about 10 minutes, and the storm cannot be accounted for by a simple pulsating electric current in a fixed circuit in the upper atmosphere. The departures of the horizontal force and declination from normal at four-minute intervals of time are shown on a vector diagram, and it appears that this was described regularly in a counter-clockwise direction throughout. The diagram shows that the disturbance field at Eskdalemuir might be obtained from that at Kew by superposing a vector which runs in an almost fixed direction (NNW. or SSE.) throughout the period investigated. After some discussion of possible causes of the storm, the conclusion is reached that to obtain a satisfactory insight into the theory of the disturbance it will be necessary to investigate the effects at other stations. J. S. Di.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

415. *Form of the Electric Discharge in X-ray Tubes.* **A. Dauvillier.** (Rev. Gén. d'Él. 1. pp. 443–458, March 24, 1917.)—This work was undertaken to determine the working conditions of tubes, and has been carried out by the aid of a Blondel oscillograph. A diagrammatical representation is given of the apparatus for photographically registering, simultaneously, the intensity of the current traversing the tube and the tension between its terminals. The form of the discharge in the two kinds of tubes actually in use is studied in detail—the Coolidge tube with a pure electronic emission, and tubes with a kathodic afflux. The former has an interesting function as a valve without inertia. Kept running under a constant tension, the tube provides a constant and continuous emission of X-rays, the electrical conditions of the discharge being very simple and clearly defined. Submitted to a variable tension, the tube presents a phenomenon of marked hysteresis, due to the presence of negative charges in the space near the electrodes, concentrated progressively by the tension wave and with the same form. The tube with kathodic afflux behaves quite differently. When the pressure of the residual gas is increased a discharge is noted analogous to that obtained with the Coolidge tube, but at low pressures the discontinuity of the kathodic emission appears, the duration of each eruption being about 5×10^{-4} sec., and independent of the form of the tension wave. The electrical resistance of the tube is much less in the inverse than in the direct sense, and discontinuity appears in both. The tube presents almost always a very apparent hysteresis phenomena; the factors of the energy expended in the bulb can only be determined under constant tension. An intermittent kathodic bundle is then obtained which is homogeneous. The state and functioning of the tube have been determined in these conditions by considering a statical characteristic with $dE/dI < 0$. Lastly, an analogy with the singing arc is made, and so an explanation of the phenomena of discontinuous kathodic emission is arrived at. A. E. G.

416. *Baese's Radiostereometer.* **J. Bergonié.** (Archives d'Él. Médicale, 25. pp. 49–58, Feb., 1917.)—The principle of this simple apparatus for localising pieces of shell, etc., is as follows :—Suppose that the two extremities of a diameter at one end of which is the screen, at the other a Crookes tube, are invariably fixed the one to the other. Then equal arcs are described by screen and tube around the common centre of rotation when the tube is moved about that centre, and the normal ray from the tube gives a fixed shadow of the projectile on the screen, providing it is situated at the centre of rotation, whatever may be the displacement. This fixed shadow is the criterion of Baese's apparatus. Whenever it occurs it is known that the projectile is at the centre of rotation. It can easily be seen that when the shadow is displaced in the same direction as the screen the projectile is between the centre of rotation and the tube, while, should it move in the opposite sense, the screen requires to be raised. A full description, with diagrams and photographs of the apparatus, is given. A. E. G.

417. *Geometrical Localisation of Projectiles.* **C. Baese.** (Archives d'Él. Médicale, 25. pp. 59–69, Feb., 1917.)—Different methods of localisation are discussed and a new apparatus briefly described which avoids all the calculations and geometrical construction common to most of the former methods. [See also preceding Abs.] A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

418. *Cutting and Chipping of Glass.* **J. F. Ronca.** (Engineering, 103. p. 221, March 9, 1917.)—The present note is in response to a previous letter by Rayleigh [see Abs. 262 (1917)] who was desirous of ascertaining if the process of chipping glass, by the contraction of a glue film on its surface, was in regular use. Ronga recalls a visit of some 12 or 15 years ago to the Idris Mineral Water Co.'s works, where he was shown plate-glass sheets (to be used for making advertising signs), the surfaces of which were chipped all over. The latter was stated to have been brought about by glueing a sheet of stout brown paper to the glass and allowing the paper to dry, which latter by its subsequent contraction was enabled to pull pieces of glass out from the entire surface of the plate. Ronga also remembers having inadvertently allowed a glue solution to dry up in a porcelain evaporating basin, which resulted in the glue pulling a piece of porcelain completely out from the bottom, leaving a hole of about 6 mm. diameter. H. H. Ho.

419. *Corrosion of Ingot Iron containing Cobalt, etc.* **H. T. Kalmus** and **K. B. Blake.** (Canada Dept. of Mines, Bull. No. 411. J. Indust. and Eng. Chem. 9. pp. 123–136, Feb., 1917. Met. and Chem. Eng. 16. p. 306, March 15, 1917. Abstract.)—In connection with the research on cobalt conducted at Queen's University, Kingston, Ontario [see Abs. 1593 and 552B (1915)] the corrosion of American ingot iron, especially sheet-roofing prepared in the open hearth, was investigated, the iron of 0·01 % of carbon being alloyed with 0·25 to 3 % of Co, Ni, or Cu. The specimens were exposed to the atmosphere and also immersed in dilute sulphuric acid for an hour. The alloy metals prevented corrosion; the protective oxide coating forming on the surface was darker in colour, denser, and more adhesive in the case of cobalt than with the other metals. Otherwise Ni and Co proved about equally effective, but it was doubtful whether the addition of more than 0·6 or 1 % of Co offered advantages. In the case of copper additions of 0·25 to 0·75 % seemed advisable. H. B.

420. *On Grain Growth.* **H. M. Howe.** (Am. Inst. Mining Eng., Bull. No. 120. pp. 2111–2117, Dec., 1916.)—A set of grains which undergo no growth in the cold will start to grow on reaching a certain temperature, and this is called the "germinative" temperature by the author. Below the germinative temperature the grains are "inert"; at the temperature they are "germinant" and above it they are "growing" or "super-germinant." Grain growth is favoured, and the germinative temperature consequently lowered, by (A) grain fineness, (B) grain-size contrast, and (C) prior plastic deformation. It is opposed by obstructions like cementite and sonims, increase of grain-size, and by grain-size equalisation. The rate of growth increases with the temperature. Difference in temperature between adjoining grains seems to exert the most potent influence. The occurrence of the allotropic changes in iron will break up any coarsening which has occurred in alpha ferrite, and should make iron less subject to grain-growth than most metals. Though long heating at a comparatively low temperature may cause great coarsening, rapid heating up to a high temperature might prevent it. F. C. A. H. L.

421. *On the Formation of Columnar and of Free Crystals during Solidification.* **H. M. Howe.** (Met. and Chem. Eng. 15. pp. 623–624, Dec. 1, 1916.)

422. *Diffusion in Liquids.* **B. W. Clack.** (Phys. Soc., Proc. 29. pp. 49–58; Disc., 58. Dec., 1916.)—Contains the results of the authors earlier experiments collected and recalculated in accordance with a theoretical correction due to Griffiths [Abs. 948 (1916)]. L. H. W.

423. *Determinations of the Compressibility of Disperse Systems.* **A. Westgren.** (Ark. för Mat., Astron. och Fysik, Stockholm, 11. No. 8. pp. 1–31, 1916.)—The compressibility of a colloid may be ascertained by two methods, viz. indirectly by observation of the temporary local concentration variations, and directly by the determination of the dependence of the osmotic pressure upon concentration, which for systems with particles of equal dimensions may be best carried out by establishing the distribution as soon as a sedimentation equilibrium is brought about. Unfortunately the author has obtained contradictory results by these two methods [see Abs. 787 (1914)]. At the outset he believed an explanation could be found in the assumption of forces acting between the particles which would be recognised in the indirect determination but not in the other method, but now the author rejects this view and takes the standpoint that one of the methods contains an error. Since the direct method appears to be free from objection, a revision of the indirect estimation has been undertaken, with the expected result. The theoretical basis of the indirect method first receives detailed attention. Following this comes a description of the application of v. Smoluchowski's views on colloid systems and of the earlier attempts to determine their compressibility. Svedberg's work in the attempt to establish Boyle's law for colloidal solutions is examined in detail, since the latter at great dilutions behave as a perfect gas but depart therefrom with increasing concentration. The direct method next comes under review and a comparison is made of the results obtained with those from the standpoint of concentration oscillations. Reasons are given for the conclusion that the latter method is not free from objection. The author follows this by determining the concentration changes within a hydrosol of sharply defined volume, full experimental details being given together with several pages of results. The conclusion is drawn that for gold whose concentrations do not exceed 72 particles per 1000 μ^3, the Boyle-Gay-Lussac law holds good. The final section contains an exhaustive criticism of the earlier experimental methods. The paper is replete with tables and illustrative curves. H. H. Ho.

424. *Molecular Refractivity and Atomic Interaction.* **L. Silberstein.** (Phil. Mag. 33. pp. 92–128, Jan., 1917.)—The author first considers Lorentz's additive law of optical refractivities, viz. if N be the molecular refractivity of a chemical compound whose molecule consists of c_1 atoms A_1, c_2 atoms A_2, etc., then it is possible to ascribe to each of the constituent atoms A_i a certain number N_i (a function of frequency only) called its atomic refractivity, such that $N = c_1N_1 + c_2N_2 + \dots$, no matter what the state of aggregation or the remaining physical conditions of the compound. To the physicist the surprising fact is that the additive law holds at all, since it means atomic interaction; and the chief object of the present paper is to lay stress precisely on what are usually called the "exceptions," and to attempt to derive from these some knowledge about the electrical interaction of the atoms of a molecule. The author first quotes a few numbers exhibiting the degree of approximation with which the additive law holds, and finds the values of certain extra

terms to be added when the law does not hold. The author remarks that the ever-growing hierarchy of rules indicating how to treat the exceptions to the law of additivity is the clearest confession of non-additivity, and then gives certain qualitative objections to the law, which, he claims, have been entirely overlooked. Thus, there are crystalline compounds, having two or even three different principal refractivities, and (although the regular arrangement of molecules is an indispensable factor) the optical anisotropy of a crystal is certainly to be attributed in its essence to the anisotropy of the molecule. Now, the constituent atoms, or rather their refractivities, being essentially isotropic, an additive combination of these is utterly impotent to give an optically anisotropic molecule. A more serious objection to the additive law is the circumstance that in many cases the compound has an entirely different distribution of absorption bands from that of the constituents, *i.e.* new free frequencies are produced and the old ones are shifted by combination or dissociation, this being closely connected with all the stated facts of huge exaltation of molecular dispersion. The resultant dispersion—and absorption—curves are not obtainable by a superposition of the component ones. The author remarks that it is hard to understand why this circumstance has been entirely kept out of account in the chemical studies of molecular refractivity. He then investigates the problem of amplifying Lorentz's additive law by taking explicitly into account the electro-optical interaction of the atoms constituting a molecule. He endeavours to find, with the simplest assumptions possible, the mutual action of the atoms of a molecule only so far as the oscillations of their dispersive particles (electrons) are concerned, and taking the molecule as being a comparatively fixed constellation of the atoms, *i.e.* treating the optical side of the question detached from all its other aspects. The general equations of atomic interaction are first developed. Following this comes the special consideration of diatomic molecules, after which formulæ for diatomic substances are discussed and illustrated. The relationship between molecular refractivity and interatomic distance is here developed, then that of free frequencies and interatomic distance, concluding with an investigation into the limit of stability. The more complex case of triatomic molecules finally receives consideration. H. H. Ho.

425. *Dispersion and the Size of Molecules of Hydrogen, Oxygen, and Nitrogen.* **L. Silberstein.** (Phil. Mag. 33. pp. 215–222, Feb., 1917.)—The author first refers to the molecular refractivity of an isotropic substance whose molecules consist of two equal atoms, a problem he had previously investigated [see preceding Abs.]. He now defines b_0 and g_0, two constant attributes of the atom, finding the ratio b_0^2/g_0 to be independent of the free wave-length. The refraction and the dispersion coefficient of the substance are then found to be simple functions of these atomic coefficients b_0, g_0 and of the interatomic distance. The dispersion is shown to have a stronger departure from additivity than the refraction. The main problem treated in the present note is an application of the general ideas laid down in the previous paper [*loc. cit.*], viz., Given the molecular refractivity of the diatomic substance (*i.e.* given its coefficients b, g); to find the atomic coefficients b_0, g_0, and therefore the atomic refractivity, also the interatomic distance. The problem is indeterminate, there being but two equations for three unknowns, and in order to convert it into a determinate one an assumption has to be made about the relationship between b_0 and g_0 in each atom. The author assumes for this purpose that the value of b_0^2/g_0 belonging to each dispersive particle or atomic resonator is equal to an exact multiple of the electronic value, *i.e.* each atomic resonator, consists of a certain number of electrons. The cases of hydrogen, oxygen, and nitrogen are next investigated. For hydrogen the central distance between the two atoms approaches very nearly the values of the semi-diameter of a molecule of hydrogen (considered as an elastic sphere) obtained by various methods based on the kinetic theory of gases. Oxygen and nitrogen show the same results, the distance differing from the heat-conduction value even much less than this does from the viscosity and the diffusion value of the semi-diameter.

The data are all collected into a convenient table. H. H. Ho.

426. *Tool-steels.* **P. Denis.** (Rev. de Mét. 13. pp. 199–249, May–June, 1916.)—A lengthy paper dealing mainly with experiments on cutting speeds. No brief abstract would be of value. L. H. W

427. *Temperature-coefficients of Free Molecular Surface Energy of Liquids between* — 80° *and* 1650° *C.* XV. *Determination of the Specific Gravity of Molten Salts, and of the Temperature-coefficient of their Molecular Surface Energy.* **F. M. Jaeger** and **J. Kahn.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 381–397, 1916.)—The calculation of the molecular free surface energy of molten salts and other compounds [see Abs. 1948 (1914), 10 (1916)] requires a knowledge of the specific gravity of the investigated liquids at temperatures ranging from — 80° to 1650° C. In many cases use may be made of the pyknometer, but this is unsuitable where measurements of volatile liquids have to be made at 0° or in a cooling mixture of salt and ice or of solid CO_2 and alcohol. A volumenometer is then employed, and this is also especially suitable with the low-boiling-point aliphatic amines, which readily absorb CO_2 and water-vapour from the air; details are given of a special method of filling the apparatus.

With organic compounds of high melting-point, and especially with inorganic salts melting at extremely high temperatures, a hydrostatic method seems the best. If, however, the substance investigated is so volatile that it sublimes rapidly on the colder parts of the suspension wire, or if the viscosity of the molten mass or its surface energy surpasses certain limits, the determination of the specific gravity must be abandoned. The apparatus devised by the authors for the hydrostatic measurements consists of a sensitive balance, from one pan of which hangs a Pt-wire about 80 cm. long and, for temperatures of 1200–1600° C., at least 0·8 mm. thick in order to prevent breaking. The wire passes through a narrow hole in the bottom of the balance case, a second hole in the board beneath, and a third hole through a water-screen, through which water is passed continuously to prevent radiation of heat from the furnace below to the balance case. At its free end the wire carries a Pt double-cone (12·1 gm.). The balance is movable vertically and horizontally. The Pt sinker and wire are weighed in the air, and the balance then lowered until the sinker is immersed in the molten substance, the surface of the latter coming to a fixed point on the wire. The temperature of the liquid is measured by means of a thermo-element and potentiometer.

The values of the specific gravity have been determined at different temperatures for a number of salts of the alkali metals, and also for thallous nitrate and stannous chloride, and the formula connecting specific gravity is deduced. In each case the values of the molecular free surface energy at the same temperatures are given, and the values of its temperature-coefficient, $d\mu/dt$, indicated. In the case of organic liquids, the normal value of $d\mu/dt$ is about 2·24 ergs per degree Centigrade, but with molten salts it is commonly much smaller, and varies between 0·8 and 1·0 erg per degree. No special regularity in the value of $d\mu/dt$ is observable, but its mean value for homologous salts of the same halogen tends to increase with increase in the atomic weight of the metal.

It has been assumed by some that the very low values of $d\mu/dt$ for molten salts indicate a high degree of association. The authors point out, however, that all conclusions based on the rule of Eötvös presume implicitly the validity of the law of corresponding states, and it is highly improbable that this law holds with electrolytically dissociated substances like molten salts, with which, moreover, the extent of dissociation doubtless varies with the temperature.

In the case of homologous molten halogenides of the alkali metals, the value of χ at any one temperature t diminishes regularly in every series with increase in the atomic weight both of the alkali metal and of the halogen. When the μ-t curves are similarly compared, such regularity seems to have vanished almost entirely. Since $\mu = \chi v^{2/3}$, it is evident that the values of v are no longer comparable in these series of salts, and it seems possible that the molecular weights M of the formula $v = M/d$, are not those calculable from the chemical formula. It may be that all these salts are dissociated to different degrees at the same temperature. T. H. P.

428. *Temperature-coefficients of Free Molecular Surface Energy of Liquids between — 80° and 1650° C. XVI. Surface Tension of Halogenides of Sulphur, Phosphorus, Arsenic, Antimony, and Bismuth.* **F. M. Jaeger** and **J. Kahn.** (K. Akad. Amsterdam, Proc. 19. 2. pp. 397–404, 1916.)—The following further compounds have been investigated: S_2Cl_2, PCl_3, PBr_3, PI_3, $AsCl_3$, $AsBr_3$, $SbCl_3$, $BiCl_3$, and $BiBr_3$.

Although the values of $d\mu/dt$ are not high and are generally lower than the normal value, 2·24 ergs per degree, they are in all cases appreciably greater than those of the molten inorganic salts (see preceding Abs.); close analogy with organic liquids is, therefore, indicated. The relative positions of the χ-t curves exhibit regularity, but, contrary to what holds with the alkali halogenides, the value of χ at one and the same temperature appears to increase with the atomic weight of the element combined with the halogen and also with the atomic weight of the latter. It is probable that the cause of this striking deviation lies in the fact that the halogens differ far less from P, As, and Sb than from the alkali metals in electrochemical characters, and in the differences between the degrees of dissociation of the two classes of compounds.

For the μ-t curves the order of arrangement is the same as for χ-t curves, whereas with the alkali halogenides the reverse is the case; in the present instance the lack of appreciable electrolytic dissociation doubtless plays a part. T. H. P.

429. *Further Determinations of Direct Osmotic Pressure.* **Berkeley** and **E. G. J. Hartley.** (Roy. Soc., Proc. 92. pp. 477–492, Aug. 1, 1916.)—Additional data are given for the osmotic pressures of aqueous solutions of cane-sugar for weight-concentrations from 8·39 to 141·1, giving osmotic pressures from 2·87 to 114 atmos. These values differ from those of Morse at lower concentrations, but become nearly identical at the upper limit of Morse's experiments.

Data are also given for α-methylglucoside from 29·87 to 117·19 atmos., for isodulcitol from 46 to 58 atmos., and for α-tetramethylferrocyanide from 5·96 to 52·82 atmos.

Osmotic pressures of electrolytes were determined for the ferrocyanides of calcium, magnesium, and sodium, and for calcium and potassium ferricyanides, as well as for 18 other salts. T. M. L.

430. *Emulsions and Suspensions with Molten Metals.* **H. W. Gillett.** J. Phys. Chem. 20. pp. 729–733, Dec., 1916.)—In the refining of aluminium chips to ingot a loss of 30 % of the metal is common and a loss of only 15 % is especially good. This loss is due primarily to the failure of the smaller molten globules to coalesce in consequence of their entanglement in the layer of floor sweepings, etc. Hence, while oxidation (and nitridation) represent the ultimate cause of the loss, the oxidation would not take place save for the very finely divided physical state of the metal. The loss may be reduced by either of two methods, both in actual use; (1) The "puddling" process, in which the chips are melted in an open iron pot, small amounts being added at a time and each addition thoroughly stirred and pushed into the main mass; the temperature is carefully kept only just above the melting-point, so that the mass is pasty but not truly fluid. (2) Large quantities of sodium chloride are mixed with the chips as a menstruum to dilute or soak up the envelope phase of dirt, preferably using with the salt a small amount—say 15 parts to 85 parts—of some fluoride, such as calcium fluoride, to dissolve the small quantity of alumina present, and heating without much stirring; this method also breaks up the emulsion and the tiny globules settle satisfactorily.

Other cases in which a molten metal or alloy forms an emulsion or suspension with a solid, a liquid, or a gas are quoted. T. H. P.

431. *Variation in the Local Concentration of the Particles in a Colloidal System.* **A. Westgren.** (Ark. för Mat. Astron. och Fysik, Stockholm, 11. No. 14. pp. 1–24, 1916.)—Formulæ recently developed [Abs. 1609 (1915), 133 (1916)] by v. Smoluchowski to express the alteration with time of the grouping of colloidal particles are tested experimentally as follows. A thin microscopic chamber is filled with a gold hydrosol having particles of equal size and closed air-tight. The preparation is then fitted to the object-table of a microscope, the colloidal particles being rendered visible by means of a cardioid condenser. Since the formulæ mentioned can partly be referred to only a geometrical plane-parallel layer within the colloid, a special arrangement is used to correspond with this limitation. The results demonstrate the validity of the expressions. T. H. P.

432. *Action of Magnesium on Solutions of Potassium Chloride.* **F. H. Getman.** (Am. Chem. Soc., J. 38. pp. 2594–2607, Dec., 1916.)—By measurement of the rate of evolution of hydrogen, the author has investigated the action of magnesium on distilled water, conductivity water, distilled water saturated with air freed from CO_2, and on solutions of potassium chloride varying in concentration from 0·1 to 0·5 normal. The p.d.'s between magnesium and solution of potassium chloride, the hydrion concentration in pure water and in solutions of potassium chloride, and the concentration of potassium chloride in a solution before and after the action of magnesium have also been determined. The results obtained are all in agreement with the formulation of the reaction between magnesium and water by the equation: $Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2$. The presence of the dissolved potassium chloride merely accelerates the reaction catalytically. T. S. P.

433. *Chemical Composition versus Electrical Conductivity.* **C. G. Fink.** (J. Phys. Chem. 21. pp. 82–86, Jan., 1917.)—Mixtures of equal weights of finely-divided thoria and tungsten have been examined. The relative volume of each sample of the thoria and tungsten was determined by placing 10 gm. in a 10 cm.^{3} graduated glass cylinder and then tapping the latter until the volume occupied by the powder underwent no further change. The relative volumes of the thoria powders varied from 0·720 to 0·238 and those of the tungsten from 0·577 to 0·113. The relative volumes of the mixtures, calculated according to the law of mixtures, agree moderately well with the experimental values, and the result is regarded as support for the view that the particles of any freshly prepared powder are of fairly uniform size. Where the ratio of the relative volume of the thoria (white) to that of the tungsten (black) is greater than 2, the mixture is white, whereas if it is less than 2 the mixture is black; 2 represents the quotient of the absolute density of tungsten (19·6) by the absolute density of thoria (9·8).

The powdered mixtures were pressed into rods and fired at 1600° to 1650° for 3 hours, being subsequently stored in a phosphorus pentoxide desiccator until the electrical resistance was measured. In one case where the relative volumes of the thoria and tungsten were respectively 0·576 and 0·235, the specific resistance of the rod was 173·0 ohms, whereas with the volumes 0·238 and 0·577, the value was 0·108 ohm.

It is concluded that, in general, the electrical conductivity of a substance depends primarily on the state and distribution of the fundamental grains or particles composing the substance, and, secondly, on the presence or absence of thin films of secondary material enveloping these ultimate grains. On the basis of this theory it is possible to account for the comparatively high conductivity of gels containing only a trace of conducting material. It is possible also to account for the marked difference in resistance between two samples of commercial copper of identical chemical composition, this depending on whether the impurity, such as sulphur, is uniformly dissolved in the metal or whether it forms a film ("cement") of copper sulphide round pure granules of copper. The latter case is to be regarded, as Bancroft suggested, as an emulsification of copper in copper sulphide. The high resistance of these surface films composed of, say, arsenic sulphide or oxide, accounts for the high specific resistance of copper containing only a trace of the impurity. T. H. P.

434. *Retarded Diffusion and Rhythmic Precipitation.* **J. Stansfield.** (Am. J. Sci. 43. pp. 1–26, Jan., 1917.)—An account is first given of earlier work on this subject, this being followed by a description of the author's experiments, the results of which are briefly as follows :—

The rate of diffusion of a reagent of given strength is retarded by increasing that of the reagent in the gelatine. Further, the total distance to which diffusion proceeds is diminished by a similar increase of strength of the reagent in the gelatine. With too close an approach of the concentrations of the two reagents, silver nitrate and potassium chromate, a continuous precipitate is formed, but under the microscope the surface of this is seen to be finely banded; these fine bands follow the same rules as regards spacing as are found with the separated bands. Separated bands are produced best by the diffusion of a concentrated silver nitrate solution against a weak chromate solution; but this may not hold in other cases. Similar results are obtainable by diffusion of a strong chromate solution against a weak silver solution, but in this case larger particles are formed. Increase in the distance between the bands has been regarded as due to progressive dilution of the reagents. It is found that rate of diffusion is an important controlling factor in this direction, and that under certain conditions the bands may be spaced equally or at decreasing distances; such conditions are discussed.

The rates of diffusion of different reagents in pure gelatine are found to differ; thus, potassium chromate solution diffuses more rapidly than lead nitrate solution of the same molecular concentration and a silver nitrate solution more rapidly than one of potassium chromate. Further, a concentrated solution of any given agent diffuses more rapidly than a weak solution. T. H. P.

435. *Influence of Pressure on Solubility.* **H. F. Sill.** (Am. Chem. Soc., J. 38. pp. 2632–2643, Dec., 1916.)—For investigating the influence of pressure on solubility the authors have designed a new type of pressure bomb, which is extremely simple in operation and permits of the withdrawal of the sample for analysis without reducing or otherwise changing the pressure. A detailed description of the apparatus and the method of using it is given. With sodium chloride in water at 25°, 100 gm. of the saturated solution contains 26·44 gm. and 26·58 gm. respectively at 1 and 250 kg. per cm.^{2}, so that an increase in pressure of 249 kg. per cm.^{2} alters the solubility by only 0·14 %. With barium hydroxide 100 gm. of the solution saturated at 25° contains 8·300 gm. of $Ba(OH)_2, 8H_2O$ at 1 megobar pressure and 8·791 gm. at 245 megobars; the heat of solution of 1 gm. of the hydrated solute at the saturation point is found to be 51·2 cals. The specific volume-change, that is, the change in volume accompanying separation from solution of 1 gm. of $Ba(OH)_2, 8H_2O$, is 0·0508 cm.^{3} The solubility data for $Ba(OH)_2, 8H_2O$ at different temperatures given by Rosenstühl and Rühlmann (Landolt and Börnstein's Tables, 1912, p. 459) lead to the value $ds/dt = 0{\cdot}288$ % for the temperature coefficient of solubility. T. H. P.

436. *Notes on Osmotic Theory.* **Berkeley.** (Phil. Mag. 33. pp. 261–276, March, 1917.)—The author points out that one of the chief difficulties in understanding osmotic theory lies in the unavoidable complexity of the notation, which arises from the fact that there are two sets of osmotic pressures, depending on which component is regarded as the solvent, and each of these sets is again capable of differentiation into another two sets according as the pressure on the solution or the pressure on the solvent is to be regarded as constant. Also, from the definition of osmotic pressure—namely, that it is the difference between the pressure on the mixture and that on the pure component when the two are in equilibrium through a semi-permeable membrane—it is easy to see that, replacing the solution by a mixture of vapours and the pure solvent by pure vapour, there will be yet another 8 sets of osmotic pressures. The definition can even be extended to cover the case of any liquid (or solution) which, when under pressure, is in equilibrium through a membrane with its own vapour under a different pressure. A diagram is given showing all but two of the possible states of osmotic equilibrium, and the author then proceeds to work out a systematic scheme of notation. The notation is then used to establish the following equivalence theorem: "If there are any sets of molecules, A, B, C, etc., each in osmotic equilibrium with a set X, then the original sets are in osmotic equilibrium with one another." Following this comes a general method for connecting the several osmotic pressures with the physical properties of the fluids under consideration. This first necessitates the following three propositions being established :—(*a*) When a solution is in osmotic equilibrium with its mixed vapour through a membrane permeable to both components, the closing of the membrane to one of the components alters neither the equilibrium nor the concentrations. (*b*) It is possible to change the pressures on the solution and its mixed vapours (separated from one another by a membrane permeable to both components) in such a manner as to keep osmotic equilibrium between them without any change in concentration taking place. (*c*) It is possible to change the pressures on the solution and its mixed vapours, separated from one another by a membrane permeable to either component only, in such a manner as to keep osmotic equilibrium between them without any change in concentration taking place. The author next investigates a possible connection between the characteristic equations of gases and of solutions. In a previous paper entitled "Solubility and Supersolubility from an Osmotic Standpoint" it was briefly outlined that when either of the two osmotic pressures of a binary liquid mixture is expressed as a function of the concentration, these functions each contain a logarithm which, in the limit, becomes infinite. A detailed exposition of this is now given. The paper concludes with a statement of the conditions to be fulfilled by an equation of state for osmotics. H. H. Ho.

437. *Measurement of Electrolytic Conductivity.* II. *The Telephone Receiver as Indicating Instrument for use with the A.C. Bridge.* **E. W. Washburn** and **K. Parker.** (Am. Chem. Soc., J. 39. pp. 235–245, Feb., 1917.)—In continuation of previous work [Abs. 183 (1917)] it is shown that a properly constructed telephone receiver is the best indicating instrument for use with the alternating-current bridge, both as regards sensitivity, ease and convenience of use, and cost. It is shown that in order to attain the max. degree of precision possible in a conductivity measurement, up to and including the extreme case of a precision of one part in 10 million, a telephone receiver with an audibility current of no smaller than 10^{-9} amp. will fulfil all possible requirements, and in most cases a less sensitive telephone is good enough. The telephone should be tuned to the frequency of the current used, and methods of mechanical, electrical, and acoustical tuning are described. Details are also given of methods for determining: (1) the variation of sensitivity with frequency, that is, the volt-sensitivity curve, and (2) the audibility current of a telephone receiver. The telephone should be connected to the bridge by means of a pair of non-inductive telephone leads, which should be enclosed in a grounded, flexible metal sheath. The telephone should also be insulated from the observer. T. S. P.

438. *Method for the Determination of Dissociation Pressures of Sulphides: Application to Covellite* (*CuS*) *and Pyrite* (*FeS_2*). **E. T. Allen** and **R. H. Lombard.** (Am. J. Sci. 43. pp. 175–195, March, 1917.)—The authors have developed a new method for the determination of dissociation pressures at comparatively high temperatures in cases where mercury gauges cannot be used. In principle it depends upon balancing the dissociation pressure of the sulphide under investigation by the vapour pressure of sulphur at a known temperature, the sulphide and sulphur being at opposite ends of an evacuated quartz tube and heated to known temperatures by separate electric furnaces. The question as to whether the sulphide is in equilibrium with the sulphur vapour is decided by analysis of the sulphide before and after the experiment; in some cases it may be settled by the change in some physical property, as, for example, in the case of covellite, which is deep blue in

colour, whilst its dissociation product, chalcocite, is dark grey. The chief advantage of the method is that the equilibrium is approached from both directions, and the investigator is not liable to be misled by false equilibria. The method can be used with compounds other than sulphides, provided there is a single volatile dissociation product which does not attack glass (or quartz glass), and which condenses at accessible temperatures. It cannot be used above 1100° to 1200°.

The dissociation-pressure curves of covellite and pyrite have been determined from about 1 mm. to 500 mm. pressure. They are represented by the equation $\log p = -A/T + B \log T + C$, the values of A, B, and C respectively being $-96397{\cdot}514$, $+356{\cdot}43227$, and $-1150{\cdot}98605$ for covellite, and $+191942{\cdot}61$, $-434{\cdot}195075$, and $+1497{\cdot}56707$ for pyrite. T. S. P.

439. *Preservation of Iron and Steel by Means of Passivifying Factors.* **T. G. Thompson.** (Iron and Steel Inst., Carnegie Schol. Mem. 7. pp. 232–298, 1916.)—The effect of various solutions of salts, varying in concentration from N/1 to N/1000, on the corrosion of iron and steel at room temperatures and at the temperature of boiling water has been studied. The iron used gave the following analytical figures (in percentages): C 0·012, P 0·004, Si 0·001, S 0·017, Mn 0·015, whilst those for the steel were: C 0·112, P 0·045, Si 0·003, S 0·052, Mn 0·388. The test-pieces were used in the form of plates, 8 cm. × 2½ cm., and the amount of corrosion was determined by weighing the cleaned plates before and after the experiment.

Under atmospheric conditions and at room temperatures the introduction of varying amounts of potassium dichromate into solutions of different concentrations of sodium sulphate, sodium chloride, magnesium sulphate, magnesium chloride, and saturated calcium sulphate, inhibits corrosion to a considerable extent. In some of the more dilute solutions a few of the test plates were rendered passive by the addition of dichromate. The differences in chemical composition and physical properties of the iron and steel employed had practically no effect in solutions of chlorides and sulphates containing potassium dichromate at room temperatures, whilst differences in behaviour were noted at 100° C. In some few cases the rate of corrosion was reduced by the addition of dichromate to dilute solutions at 100°, but with N/1 and N/10 solutions of chlorides and sulphates the addition of dichromate to the hot solutions was decidedly injurious to the iron and steel. It follows that the commercial application of potassium dichromate to boiler waters is not practicable, the results being uncertain and the cost too great.

At room temperatures the addition of disodium phosphate to solutions of sodium sulphate and sodium chloride reduces the rate of corrosion of iron and steel, but at 100° the rate of corrosion is increased, even when small amounts only are added. The phosphate does not make the iron or steel passive at all, but gives rise to slightly different actions with the two kinds of metal.

The rate of solution of zinc on galvanised iron is increased by the addition of dichromate to solutions of sodium sulphate and sodium chloride. Iron cannot be rendered passive under boiler conditions in N/10 solutions of chlorides and sulphates when varying amounts of potassium dichromate are added and the iron made the anode in an electric circuit. T. S. P.